FINAL

ENVIRONMENTAL IMPACT ASSESSMENT
FOR THE
WESTMORLAND/ALBERT
INTEGRATED WASTE MANAGEMENT FACILITY

Submitted by:

Westmorland/Albert Solid Waste Provisional Committee

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Date:

September 30, 1991

Amendments made and added to October 28, 1991

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92-01535/

ABSTRACT

This report contains the results of an environmental impact assessment of three potential sites for the Westmorland/Albert Integrated Waste Management Facility. The sites are described as the Delong Drive Site, the Berry Mills Road Site, and the Route 126 Site.

The assessment has been carried out in accordance with the Guidelines prepared by the NBDOE. A baseline of information on particular aspects of the environment at each site is developed. Specifically information is developed on the geology, hydrogeology, the overburden and bedrock characteristics, the surface water courses, the terrestrial and aquatic biology, the socio-economic system and the transportation system.

Project activities are described, including waste generation, composition and delivery, site layout and related infrastructure, landfill operation, site closure and monitoring. Potential effects of the proposed project on the existing environment were considered, and interactions where impacts are likely to occur have been identified.

Although all three sites were found to have some impacts on the existing environment, none were major. Where appropriate, specific components for the facility have been identified and mitigative measures and monitoring programs have been recommended. All three sites are considered to be suitable for the development of the intended Integrated Waste Management Facility.

ENVIRONMENTAL IMPACT ASSESSMENT

WESTMORLAND/ALBERT

INTEGRATED WASTE MANAGEMENT FACILITY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF EXHIBITS

EXECUTIVE SUMMARY

PAGE

1.0 INTRODUCTION 1.1

1.1 Background to the Study 1.1

1.1.1 WESTMORLAND/ALBERT SOLID WASTE PROVISIONAL COMMITTEE *1.1*

1.1.2 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS *1.2*

1.2 Integrated Waste Management Facility 1.3

1.2.1 PREVIOUS STUDIES *1.4*

1.2.2 PROJECT RATIONALE *1.4*

1.2.3 COMPONENTS OF THE WASTE MANAGEMENT STRATEGY *1.6*

1.2.4 SITE SELECTION PROCESS *1.6*

1.3 Conduct of the Study 1.7

1.3.1 GEOLOGY, HYDROGEOLOGY AND GROUNDWATER *1.8*

1.3.2 SURFACE WATERCOURSES AND TERRESTRIAL BIOLOGY *1.8*

1.3.3 AQUATIC BIOLOGY *1.9*

1.3.4 COLLECTION OF SOCIO-ECONOMIC DATA *1.9*

1.3.5 PUBLIC MEETINGS *1.10*

1.3.6 ASSESSMENT OF IMPACTS *1.11*

TABLE OF CONTENTS (continued)

PAGE

2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT 2.1

2.1 Study Boundaries 2.1

2.1.1 TEMPORAL 2.1

2.1.2 SPATIAL 2.1

2.2 Geological/Hydrogeological Setting 2.4

2.2.1 BEDROCK AND SURFICIAL GEOLOGY 2.4

2.2.2 HYDROGEOLOGICAL BACKGROUND 2.6

2.2.3 INVESTIGATION OF INDIVIDUAL SITES 2.8

2.3 Overburden and Bedrock Characteristics 2.35

2.3.1 SUBSURFACE INVESTIGATION 2.35

2.3.2 SOIL EROSION 2.41

2.3.3 EROSION CONTROL 2.42

2.4 Surface Watercourses 2.43

2.4.1 GENERAL CHARACTERISTICS 2.43

2.4.2 WATER QUALITY 2.49

2.4.3 RESULTS FROM PREVIOUS WATER QUALITY STUDIES 2.51

2.5 Biological Setting 2.54

2.5.1 TERRESTRIAL BIOLOGY 2.54

2.5.1.1 Topography 2.54

2.5.1.2 Forest Stand Descriptions 2.54

2.5.1.3 Wetlands 2.55

2.5.1.4 Fauna 2.60

2.5.1.5 Waterfowl 2.67

TABLE OF CONTENTS (continued)

PAGE

2.5.2 AQUATIC BIOLOGY 2.67

2.5.2.1 Fish Habitat 2.67

2.5.2.2 Electrofishing Results 2.73

2.5.2.3 Benthic Invertebrates 2.74

2.6 Socio-Economic System 2.75

2.6.1 DEMOGRAPHIC AND ECONOMIC STRUCTURE 2.75

2.6.1.1 Population 2.75

2.6.1.2 Socio-Economic Structure 2.81

2.6.2 LAND USE AND RESOURCES 2.83

2.6.2.1 Land Use and Ownership 2.83

2.6.2.2 Land Marketability 2.86

2.6.3 INFRASTRUCTURE AND SERVICES 2.87

2.6.3.1 Municipal 2.87

2.6.3.2 Rail 2.87

2.6.3.3 Power Line 2.88

2.6.3.4 Highway System 2.88

2.7 Transportation 2.88

2.7.1 CURRENT USAGE AND CONDITION OF ROADS LEADING TO THE SITE 2.89

2.7.2 TRAFFIC 2.90

2.7.3 SAFETY 2.93

3.0 DESCRIPTION OF PROJECT ACTIVITIES 3.1

3.1 Wastes 3.1

3.1.1 MUNICIPAL WASTE GENERATION AND COMPOSITION 3.1

TABLE OF CONTENTS (continued)

PAGE

3.1.2 *COLLECTION AND DELIVERY OF MUNICIPAL WASTES* 3.3

3.1.3 *OTHER WASTES* 3.4

3.2 Site Layout and Related Infrastructure 3.4

3.2.1 *DEVELOPMENT OF THE LANDFILL AREA* 3.4

3.2.2 *DEVELOPMENT OF OTHER COMPONENTS* 3.9

3.3 Landfill Operation 3.11

3.3.1 *GENERAL* 3.11

3.3.2 *CONTROL OF WASTE TYPES* 3.12

3.3.3 *CONTROL OF WASTE DELIVERY* 3.13

3.3.4 *DISPOSAL ACTIVITIES* 3.14

3.3.5 *CONTROL OF SURFACE RUNOFF* 3.14

3.3.5.1 *Soil Erosion* 3.15

3.3.5.2 *Sediment Reduction* 3.15

3.3.6 *CONTROL OF LEACHATE* 3.15

3.3.6.1 *Effluent Standards* 3.16

3.3.6.2 *Containment and Collection* 3.19

3.3.6.3 *Treatment* 3.23

3.3.7 *CONTROL OF GAS EMISSIONS* 3.29

3.3.7.1 *Gas Generation* 3.30

3.3.7.2 *Derivation of Gas Generation Model for Landfill* 3.31

3.3.7.3 *Landfill Design for Gas Extraction* 3.33

3.3.7.4 *Uses for Landfill Gas* 3.33

3.4 Site Closure and Reclamation 3.34

TABLE OF CONTENTS (continued)

PAGE

4.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS 4.1

4.1 Identification of Issues 4.1

4.2 Groundwater Resources 4.6

4.2.1 IMPACTS AND MITIGATION 4.6

4.3 Surface Watercourses 4.9

4.3.1 IMPACTS 4.9

4.3.1.1 Suspended Sediments 4.9

4.3.1.2 Leachate 4.21

4.3.2 MITIGATION 4.28

4.3.2.1 Suspended Sediments 4.28

4.3.2.2 Leachate 4.28

4.4 Wildlife Habitat 4.30

4.4.1 IMPACTS 4.30

4.4.2 MITIGATION 4.32

4.5 Aquatic Resources 4.33

4.5.1 IMPACTS OF SUSPENDED SEDIMENTS ON FISH AND BIOTA 4.34

4.5.2 IMPACTS OF LEACHATE ON FISH AND BIOTA 4.35

4.5.3 MITIGATION MEASURES 4.35

4.6 Socio-Economic System 4.37

4.6.1 SITE CONSTRUCTION AND OPERATIONS 4.37

4.6.1.1 Impacts and Mitigation Measures on Human Health and Safety 4.37

4.6.1.2 Impacts and Mitigation Measures on Economic Structure 4.39

TABLE OF CONTENTS (continued)

PAGE

4.6.1.3 Impacts and Mitigation Measures on Land Use 4.40

4.6.2 TRAFFIC AND TRANSPORTATION 4.42

4.6.2.1 Impacts 4.42

4.6.2.2 Mitigation Measures 4.43

5.0 MONITORING REQUIREMENTS 5.1

5.1 Compliance Monitoring 5.1

5.1.1 GROUNDWATER MONITORING 5.1

5.1.2 SURFACE WATER QUALITY MONITORING 5.2

5.2 Environmental Effects Monitoring 5.2

5.2.1 MONITORING SURFACE WATERCOURSES FOR SEDIMENT 5.2

5.2.2 MONITORING SURFACE WATERCOURSES FOR LEACHATE 5.3

5.2.3 SURFACE WATER MONITORING VARIABLES AND TIME TABLES 5.3

5.2.4 MONITORING OF BENTHIC INVERTEBRATES AND AQUATIC RESOURCES 5.4

5.2.5 MONITORING OF SOCIO-ECONOMIC IMPACTS 5.5

6.0 COSTS OF SITES 6.1

REFERENCES

PERSONAL COMMUNICATIONS

TABLE OF CONTENTS (continued)

APPENDIX A Guidelines and Terms of Reference for an Environmental Impact Assessment of the Westmorland/Albert Integrated Waste Management Facility

APPENDIX B Resumes of Previous Studies

APPENDIX C Boring Logs

APPENDIX C1 Borehole Well Logs

APPENDIX D Drawing 1

APPENDIX E Water chemistry data for streams adjacent to proposed waste management facility sites

APPENDIX F Electrofishing Results

APPENDIX G Drawings 1-1, 1-2, and 1-3.

LIST OF TABLES

		Page
Table 1-1	Existing Sites for the Disposal of Municipal Waste	1.5
Table 2-1	Delong Drive Site: Test Hole Depths	2.14
Table 2-2	Delong Drive Site: Groundwater Elevations	2.16
Table 2-3	Delong Drive Site: Hydraulic Conductivity Values	2.17
Table 2-4	Berry Mills Road Site: Test Hole Depths	2.24
Table 2-5	Berry Mills Road Site: Groundwater Elevations	2.27
Table 2-6	Berry Mills Road Site: Hydraulic Conductivity Values	2.28
Table 2-7	Route 126 Site: Test Hole Depths	2.31
Table 2-8	Route 126 Site: Groundwater Elevations	2.33
Table 2-9	Route 126 Site: Hydraulic Conductivity Values	2.35
Table 2-10	Water quality guidelines and requirements pertaining to effluent discharges and surface water quality guidelines for the protection of aquatic life in streams adjacent to the Westmorland/Albert Integrated Waste Management Facility	2.46
Table 2-11	Surface Water Quality Results (median values) Measured for Streams Adjacent to Proposed Waste Management Facility Sites: A) Delong Drive Site, B) Berry Mills Road Site, C) Route 126 Site	2.47
Table 2-12	Total and Faecal Coliform Bacteria Counts from select locations within the Petitcodiac Basin Area and the Cocagne River adjacent to proposed sites: A) Delong Drive Site, (B) Berry Mills Road Site, and (C) Route 126 Site	2.48
Table 2-13	Median Water Chemistry Values for Streams Adjacent to Proposed Waste Management Facility Sites A) Delong Drive Site, B) Berry Mills Road Site, and C) Route 126 Site	2.53

LIST OF TABLES (continued)

		Page
Table 2-14	Forest stand descriptions for proposed sites based on New Brunswick Forest Development Survey maps (4311 ha) and ground cruises in December, 1990 & January, 1991	2.56
Table 2-15	Current habitat suitability ratings for valued terrestrial ecosystem components potentially influenced at the proposed sites. Values are based on site size (i.e. 0.875 units per ha) and forest stand composition (maturity state and canopy species) from map interpretation and site visits. The % values represent the habitat suitability value as a portion of the maximum achievable value for the stand (e.g. Route 126 Site: Deer; 106.26/240 = 44.28%).	2.63
Table 2-16	Definitions and Criteria for Use in Salmonoid Habitat Classification	2.69
Table 2-17	Salmonoid Nursery Area Habitat Evaluation in 1989 on the Cocagne River System Tributaries Adjacent to a Proposed Integrated Waste Management Facility	2.70
Table 2-18	Some Physical Parameters Pertinent To Assessing Salmonoid Nursery Area Quality For Select Stream Sections On Watercourses Adjacent To Proposed Sites	2.72
Table 2-19	Group presence and abundance rank (P) of major groups of benthic invertebrates encountered from 5 spot checks at sampling stations on: Jonathan Creek, Somers Creek, and the Cocagne River mainstem	2.76
Table 2-20	Populations of Westmorland/Albert Region and New Brunswick, 1971-1986	2.77
Table 2-21	Population Growth Rates of Westmorland/ Albert Region and New Brunswick, 1971-1986	2.77
Table 2-22	Populations and Population Growth Rates of Incorporated Areas in the Westmorland/Albert Region	2.79
Table 2-23	Populations and Population Growth Rates of Parishes in the Westmorland/Albert Region	2.80
Table 2-24	Westmorland/Albert Region Population Projections, 1994-2014	2.81
Table 2-25	Employment by Sector for 1990	2.82

LIST OF TABLES (continued)

		Page
Table 2-26	Daily Traffic Generated on Selected Route Sections by Delong Drive Waste Management Operation	2.91
Table 2-27	Daily Traffic Generated on Selected Route Sections by Berry Mills Waste Management Operation	2.92
Table 2-28	Daily Traffic Generated on Selected Route Sections by Route 126 Site Waste Management Operation	2.94
Table 2-29	Impact on Traffic Accident Rate	2.95
Table 3-1	Predicted Waste Tonnage for Westmorland/Albert Counties	3.2
Table 3-2	Leachate Characteristics	3.17
Table 3-3	Range of Leachate Composition	3.18
Table 4-1	Groundwater Velocity (meters/year)	4.10
Table 4-2	Groundwater Flow Time Span per Specified Distance	4.12
Table 4-3	Groundwater Flow Distance per Specified Time Span	4.13
Table 4-4	Impacts to Fish and Wildlife Resources	4.20
Table 4-5	Extreme Daily Flows in Watercourses Adjacent the Delong Drive, Berry Mills Road and Route 126 Sites	4.23
Table 4-6	Leachate Parameter Concentrations Assumed for Computational Purposes in Worst Case Scenario	4.24
Table 4-7	Potential Effects of Leachate Spill on Selected Water Quality Parameters During the Extreme Minimum Daily Flow Period	4.26
Table 4-8	Potential Effects of Long-Term Leachate Discharge on Selected Water Quality Parameters During the Summer Low Flow Period	4.27
Table 6-1	Comparison Costs of Landfill Sites	6.1
Table 6-2	Comparison Costs of Waste Management Systems	6.2

LIST OF EXHIBITS

		Page
Exhibit 2-1	Proposed Sites	2.2
Exhibit 2-2	Westmorland/Albert Integrated Waste Management Facility - Geological Map	2.5
Exhibit 2-3	Westmorland/Albert Integrated Waste Management Facility - Test hole Construction	2.11
Exhibit 2-4	Delong Drive Site - Location of Linears	2.13
Exhibit 2-5	Delong Drive Site - Test Hole Locations	2.15
Exhibit 2-6	Delong Drive Site - Groundwater Flow - Test Hole Depth: 7.6 m	2.18
Exhibit 2-7	Delong Drive Site - Groundwater Flow - Test Hole Depth: 22.8 m	2.19
Exhibit 2-8	Berry Mills Road Site - Location of Linears	2.21
Exhibit 2-9	Berry Mills Road Site - Test Hole Locations	2.23
Exhibit 2-10	Berry Mills Road Site - Groundwater Flow - Test Hole Depth: 7.6 m	2.25
Exhibit 2-11	Berry Mills Road Site - Groundwater Flow - Test Hole Depth: 22.8 m	2.26
Exhibit 2-12	Route 126 Site - Location of Linears	2.29
Exhibit 2-13	Route 126 Site - Test Hole Locations	2.32
Exhibit 2-14	Route 126 Site - Groundwater Flow - Test Hole Depth: 22.8 m	2.34
Exhibit 2-15	Potential waste management sites: (A) north of Delong Drive and (B) south of Berry Mills Road showing the location of sedimentation and leachate collection ponds, and the locations of water quality and aquatic habitat evaluation (A) sampling stations (#1-#16) on Jonathan Creek, Somers Creek, and Michael's Creek	2.44

LIST OF EXHIBITS (continued)

		Page
Exhibit 2-16	Potential waste management site east of Route 126 (Site C) showing the location of sedimentation and leachate collection ponds, and the locations of water quality and aquatic habitat evaluation (A) sampling stations (#17-#22), on the Cocagne River and Shaw Brook. Tributaries of note are "D" and Shaw Brook where rectangles show locations where habitat evaluation was carried out earlier by other agencies.	2.45
Exhibit 2-17	Past and Present Surface Water Quality Monitoring Stations for the Petitcodiac Basin Area and Eastern Shore Areas of New Brunswick and the locations of the three (3) potential sites (a,b,and c) for the Westmorland/Albert Integrated Waste Mangement Facility (I.W.M.F.)	2.52
Exhibit 2-18	A composite of New Brunswick Forest Development Survey maps for the Delong Drive and Berry Mills Road Sites showing site boundaries (outside perimeter) and constraint lines, forest stand types (cutovers, wetlands, softwood, mixed wood, hardwood), and signs of deer (X)	2.57
Exhibit 2-19	A composite of New Brunswick Forest Survey Maps for the Route 126 Site showing site boundaries (outside perimeter) and constraint lines, forest stand types (cutovers, wetlands, softwood, mixed wood, hardwood), moose signs (M°) and wintering areas (M^{1}) from 1989, moose signs (m) from 1991, and deer signs (1989: "O"; 1990-91: "D").	2.58
Exhibit 3-1	Composition of Municipal Solid Waste for the Atlantic Region.	3.2
Exhibit 3-2	Preliminary Landfill Gas Production Model.	3.32

LIST OF EXHIBITS (continued)

		Page
Exhibit 4-1	Initial Impact Screening - Delong Drive Site.	4.2
Exhibit 4-2	Initial Impact Screening - Berry Mills Road Site.	4.3
Exhibit 4-3	Initial Impact Screening - Route 126 Site.	4.4
Exhibit 4-4	Berry Mills Road Site Hypothetical Leachate Leak Plume Front Location Over Time	4.14

EXECUTIVE SUMMARY

INTRODUCTION

This report contains the results of an Environmental Impact Assessment (EIA) for an Integrated Waste Management Facility to be located on one of three sites in the Greater Moncton vicinity. The three potential sites are identified as the Delong Drive Site, the Berry Mills Road Site, and the Route 126 Site.

During the course of the EIA process, as information on the sites has become available, the Provincial Committee has ranked the sites in order of preference. The ranking is as follows: Berry Mills Road Site, Delong Drive Site, Route 126 Site. It is the intent of the Committee to proceed with the Integrated Waste Management Facility at the Berry Mills Road Site unless circumstances arise which require a change in preference.

The selection of a site for the Integrated Waste Management Facility in the Westmorland/Albert Region has been under study since August 1988. A number of studies have been conducted to date and serve as background to this EIA. Among others, these include: Waste Audit, Waste Management Alternatives, Site Selection Criteria Scoring System, Site Selection Report, Collection and Transportation Analysis, Assessment of Landfill Leachate Treatment Options, etc.

The project rationale,the components of the waste management strategy, as well as the site selection process are described before detailing the public concerns pertaining to this project, and the manner in which the EIA is conducted.

THE EXISTING ENVIRONMENT

Study boundaries, including temporal and spatial bounds for the three sites, are established. Regarding time, the landfill component of the proposed facility is expected to operate for a minimum of 25 years. Spatially, both the Delong Drive and Berry Mills Road Sites are privately owned and are adjacent each other in an industrial area near the Moncton Industrial Park. The Route 126

Site is Crown land located approximately 1.6 km north of Indian Mountain Road and 1.8 km east of Route 126.

An investigation of the three individual sites was conducted to augment existing geological and hydrogeological data. The surficial deposits underlying the study areas are generally of low permeability. Bedrock at the Delong Drive and Berry Mills Road Sites is characterized by flat-lying sedimentary rocks consisting of red to brown claystone, siltstone and sandstone of the Salisbury Formation. Bedrock at the Route 126 Site is characterized by red and green siltstone, sandstone and claystone with minor conglomerate. The till layer depth at these sites ranges from 1.5 to 8.0 meters. Topsoil thickness ranges from 10 to 100 cm. For the Delong Drive and Berry Mills Road Sites, the groundwater flow is in a southwesterly direction, while for the Route 126 Site, the groundwater flow is in a northwesterly direction.

In order to determine the existing water quality in Michael's Creek, Jonathan Creek, Somers Creek, Shaw Brook and the Cocagne River, a total of 4 samples were collected at each of the 18 sampling stations identified on these watercourses. Following chemical and bacteriological analysis, water quality was found to be poor in Michael's Creek as well as in parts of Jonathan and Somers Creeks.

Electrofishing was conducted in Jonathan Creek, Somers Creek and the Cocagne River in order to gain knowledge on aquatic habitat in these watercourses. Although Jonathan Creek and Somers Creek were found to be suitable habitat for salmon and brook trout, neither of these species were encountered during electrofishing. The Cocagne River is also considered to be a suitable habitat for these species.

In reviewing the terrestrial biology, white birch, spruce and balsam fir were the three species of trees most often encountered on the sites. Portions of each of the three sites have already been clear cut. From a wildlife perspective, the Route 126 Site is considered to be the most sensitive of the three sites as potential deer and moose wintering areas are identified within or in the vicinity of this site.

For the transportation issue, access roads, traffic and safety are addressed. Both the Delong Drive and Berry Mills Road Sites can be accessed by either Delong Drive or Berry Mills Road. The anticipated additional traffic is not expected to impact on the various transportation routes that lead to either of these sites. For the Route 126 Site, the access would be from the Melville Road. The anticipated traffic increase is expected to be insignificant in comparison to the current traffic levels and capacity of the highway systems. There is some existing congestion on Route 126 between the TCH and the intersection of Front Mountain Road due to traffic at Magnetic Hill during peak tourism season.

PROJECT ACTIVITIES

Once the proposed waste management facility is operational, a region wide collection and transportation system will have been developed.

The proposed facility will be capable of safely handling a variety of non-hazardous wastes. Landfillable wastes include household refuse, institutional wastes (e.g. food wastes) and some commercial wastes. Special areas will be set up to handle wastes that are not easily landfilled, such as sludge wastes from the GMSC, construction and demolition wastes, bulk recyclables and household hazardous wastes. Wastes that will not be accepted at the landfill include biomedical wastes, chemical wastes, industrial hazardous wastes, petroleum wastes, fish wastes, and meat processing wastes.

The sanitary landfill component of the facility will include:

- access road (on-site);
- borrow pits;
- control zone (buildings, salvage area, weigh scales, etc.);
- constrained areas (on-site);
- environmental monitoring stations;
- leachate recovery/treatment facility;
- ponds (fire & sedimentation);
- property boundaries and setbacks;

- visual buffers; and
- working cells.

Other components which will be developed within the Integrated Waste Management Facility include a public education program promoting waste reduction and major recycling and composting operations. All facility operations will be overseen by trained personnel.

Control of waste types delivered to the facility will be ensured by a public information program, by signage stating specifically what wastes are acceptable at the site, and finally by the site scale operator and equipment operators. In order to control access, a fence will be constructed around the perimeter of the site, and signs will be erected to identify the days and hours of operation. Upon arrival at the facility, all vehicles and trucks will report to the scalehouse, where they will then be directed where to unload their wastes, recyclables, etc. Control of disposal activities on-site will be ensured by site attendants. To prevent disposal of wastes along the roadside, the New Brunswick Department of the Environment must monitor and take action against any violators.

The working cells proposed for the landfill will be approximately 6 hectares in area with a working depth of 15 meters. This cell size will provide for approximately five years of operation. A liner system for leachate containment will be installed on the bottom. Above the liner, a leachate recovery system will be installed in a drainage layer.

The collected leachate will be treated on site in a pre-treatment facility consisting of a four cell aerated lagoon system. Effluent will meet the requirements of the sewer bylaw of the City of Moncton and the Greater Moncton Sewage Commission (GMSC). Effluent from the pre-treatment facility will either be piped (Delong Drive Site or Berry Mills Road Site) or trucked (Route 126 Site) to the city sewer for further treatment in the GMSC plant. No leachate will be discharged into any watercourse.

In order to prevent the accumulation of methane gas in the landfill or its infiltration into the groundwater system, five vertical gas wells will be installed for each hectare of waste disposal area.

Gas collection piping will be attached to the wells and will transfer the gas to a single point source from where it will be flared (waste burned).

In order to control surface runoff, soil erosion and sedimentation, all surface runoff will be directed to sedimentation ponds. Diversion ditches will be vegetated and sediment traps will be used. The first structures constructed on the sites will be the sedimentation control devices.

As the capacity of each cell is reached, the cells will be capped and the surface of the cells will be seeded. Periodic maintenance of the final cover will be required. Leachate treatment, gas flaring, and monitoring of the site and surrounding watercourses will continue for many years following reclamation of the site.

ENVIRONMENTAL IMPACT

A screening of impacts was completed for the construction, operational and closure/post-closure phases of the proposed waste management facility. Interactions considered to be possible impacts or definite impacts are subjected to further discussion.

Should the leachate containment system fail, contamination of groundwater resources is a possibility. However, the use of a well designed monitoring program to detect leachate migration, is proposed to permit remediation measures to be undertaken in sufficient time to prevent extensive spread of contaminants.

In terms of surface water quality and aquatic habitat, Michael's Creek is the watercourse least likely to be impacted by an accidental release of suspended sediments or leachate. This is due to poor water quality and to the extent of industrial development adjacent to Michael's Creek. However, for the protection of all watercourses and aquatic resources, mitigation measures will be taken at the chosen site. The construction and maintenance of sediment holding ponds as well as the use of erosion control features during access road construction will aid in reducing the probability of accidental sediment releases. To eliminate the effects of leachate on receiving streams, it will be contained, collected and pre-treated on-site before being piped or trucked to the city sewer system and further treatment in the GMSC plant. Sampling of leachate will be undertaken to ensure the pre-treatment system is operating properly, and sampling of watercourses will be undertaken to ensure early detection of any accidental contamination.

Overall loss of wildlife habitat will be minimal if facility site development proceeds at either of the Delong Drive or Berry Mills Road Sites since large tracts of softwood and hardwood forest have already been harvested. The few wildlife at these sites would be displaced to the west. Should the facility be developed on the Route 126 Site, construction activities will remove potential calving grounds for moose. Any deer or moose on this site will likely be displaced to the east and west of the site along the mainstem of the Cocagne River and its tributaries.

Permanent residents living near the three sites will have a minimal impact from development of the facility. In fact, there are no residences located less than one kilometre from all three potential sites. Both the Delong Drive and Berry Mills Road Sites are remote enough that they are not visible from residences or major thoroughfares within 4 km. Part of Route 126 Site is visible from some residences and certain areas along Indian Mountain Road at a distance of 1.6 km. Berms can be constructed to restrict this visibility.

There are no negative impacts expected at either of the Delong Drive or Berry Mills Road Sites on private properties adjacent to these sites regarding land use. These sites are undeveloped at present and will likely remain as such in the near future with adjacent development being restricted to compatible uses such as light industry. Should the Route 126 Site be selected, development of this site would likely remove it from softwood lumber production for at least 60-80 years.

The amount of traffic that will be generated on major roads or highways will be insignificant in terms of the existing traffic levels on these routes. With a few exceptions, the routes that will be impacted by the waste management facility are easily handling their peak traffic. The potential areas of concern include the summer months at Magnetic Hill (Route 126 Site) which is an existing condition, the intersection of Berry Mills Road, the CN main line and the site access road (Delong Drive or Berry Mills Road Site), and the existing congestion at the intersection of Edinburgh Drive and St. George Street (Delong Drive Site or Berry Mills Road Sites). Road upgrading and traffic control lights presently planned for Edinburgh/St. George Street and Magnetic Hill, caution signs, the construction of an all weather access road, warning systems at the CN crossing and acceleration/deceleration lanes at the Berry Mills Road will aid in minimizing any traffic and safety concerns.

MONITORING REQUIREMENTS

Once the Integrated Waste Management Facility is in operation, a monitoring program will be set up to assess the accuracy of the predicted impacts and to ensure early detection of any potential impacts so that mitigative measures may be undertaken at once.

Sampling and analysis of groundwater and surface water, as well as electrofishing and benthic invertebrate sampling runs, will occur at regular intervals throughout the life of the facility. A record will also be kept of various complaints regarding noise, litter and other nuisance parameters near the site and along haul routes.

COSTS OF SITES

Capital costs and operation and maintenance costs have been developed for each of the proposed sites. The estimated cost per tonne for landfill only ranges from $33.74 to $37.57 depending on which site is selected and which access road is used. On a household basis the estimated cost for collection, transportation and landfill is estimated at $67 each. The estimated cost per household if a central processing facility, including collection, transportation, recycling and composting, is developed is $100 each.

1.0 INTRODUCTION

1.1 Background to the Study

This report contains the results of an Environmental Impact Assessment (EIA) for an Integrated Waste Management Facility to be located in the Greater Moncton vicinity, Westmorland County, New Brunswick. The assessment was undertaken on behalf of the Westmorland/Albert Solid Waste Provisional Committee and will be submitted to the New Brunswick Department of the Environment (NBDOE) as part of the approval process for the establishment of the integrated waste management facility.

1.1.1 WESTMORLAND/ALBERT SOLID WASTE PROVISIONAL COMMITTEE

The New Brunswick Department of the Environment (NBDOE) has implemented a waste management program for the Province. This plan will result in the replacement of the existing network of dumps by regional waste management systems which incorporate state-of-the-art facilities, collection networks, and recycling operations.

The Westmorland/Albert Solid Waste Provisional Committee (WASWPC) was established by the Minister of the Environment in December 1987, to develop and implement a long term strategy for handling the solid waste generated in the Westmorland/Albert Region. The Committee, comprised of representatives from the fourteen (14) municipalities and thirty-four (34) local service districts in the two counties, has embarked on a planning process designed by the Department of the Environment. Every member has put in long hours of study and consultation, and reports have been made regularly to the various communities throughout the process.

Much of the work was carried out by two subcommittees, the WASWPC Staff and Executive, and a team of consultants under the direction of Acadia Consultants and Inspectors Limited. One subcommittee was responsible for the technical aspects of the new solid waste management plan, and the other for providing public information and soliciting input from the residents of the Region.

The Committee proposes to build a sanitary landfill as the initial major component in its waste management strategy for the Region. This landfill will replace the unsuitable dump sites presently being used in Westmorland and Albert Counties. Three potential sites have been identified which meet siting criteria. The project has been registered under the Environmental Impact Assessment Regulation of the Province of New Brunswick Clean Environment Act (Regulation 87-83).

The proposed waste management strategy will also include public education, waste reduction, recycling and composting. The integrated waste management facility will include administration and maintenance areas, the recycling operation, the sanitary landfill, a leachate treatment system, a composting operation, construction and demolition waste area and other components, such as collection areas for white goods and metals, for household hazardous wastes, etc.

Although much effort has been made by the Committee to better handle the Region's waste, neither the Committee nor the future Solid Waste Commission will have any control over unregulated dumping of waste in the Region. However, as the protection of the environment is clearly becoming one of society's most important issues, individuals as well as industries are becoming more conscious of their actions. It is expected that increased awareness, as well as education efforts, will aid in diminishing unregulated dumping. Once the integrated waste management facility is operational, in order to mitigate against such actions, signs should be erected at each of the Region's closed dump sites, so as to discourage any dumping at these sites. However, as it is a problem under provincial jurisdiction, there is little else that can be done by the Commission. It is the responsibility of the Operations Branch of the N.B.D.O.E. to police properly and to take action against a polluter. They are responsible for prosecuting any violation of the Clean Environment Act.

1.1.2 ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

Since 1975, it has been the policy of the Province of New Brunswick to review all major developments with government involvement to determine the need for an EIA. Following extensive review a final regulation was adopted in 1987 by Government. The prime difference between Regulation 87-83 and the earlier EIA policy is that the requirement for registration and screening now extends to projects proposed by municipalities and private developers, as well as government-sponsored undertakings.

Regulation 87-83 describes the process to be followed (in order for the Proponent to obtain a decision from the Lieutenant-Governor-in-Council for the project. The first step in the process is that the Proponent (WASWPC) registers the proposed project with N.B.D.O.E. If the project is determined to be of sufficient impact to warrant a detailed EIA, the following steps are required:

- *Draft guidelines are prepared by N.B.D.O.E. with the aid of a Review Committee comprised of technical specialists from various government agencies.*
- *Guidelines are then reviewed by the Public.*
- *Final guidelines are issued to the WASWPC.*

- *WASWPC submits a draft Terms of Reference in response to EIA guidelines.*
- *Terms of Reference are finalized through a consultation process.*
- *The WASWPC undertakes the EIA.*
- *A draft EIA is filed with the Minister of N.B.D.O.E. for review.*
- *The draft EIA is reviewed and modified as required.*
- *The final EIA report is filed.*
- *The Minister accepts for public review.*
- *An EIA Summary Report and a General Review Statement are prepared.*
- *Public meetings are held to address the final EIA report.*
- *Public comments and concerns are submitted to the Minister.*
- *The Lieutenant-Governor-in-Council decides on acceptability of the project.*

N.B.D.O.E. has screened the project and confirmed that a full EIA is required. Draft guidelines for an environmental assessment of the project were issued for public review. No written submissions were received from the Public and final guidelines have been prepared by N.B.D.O.E. These are included in Appendix A of this document.

Upon receipt of guidelines, and based on further discussions with representatives of WASWPC and N.B.D.O.E., terms of reference were drafted. These are also included in Appendix A and summarize the fundamental components to be considered in an EIA: the project rationale, site selection process, project description, description of the existing environment and valued ecosystem components, establishment of a context of significance for impacts, prediction of environmental effects, and a description of monitoring and mitigation measures.

1.2 Integrated Waste Management Facility

There are a total of twenty-one (21) solid waste disposal dumps in the Westmorland/Albert Region, eighteen (18) of which are public sites and three (3) of which are privately owned. Twelve (12) of the public sites are operated by municipalities, five (5) by the provincial Department of Transportation, and one (1) by the provincial Department of Supply and Services. These are listed in Table 1-1. All solid waste disposal dumps listed in Table 1-1 will be closed with the opening of the Integrated Waste Management Facility.

1.2.1 PREVIOUS STUDIES

The selection of a site for the Integrated Waste Management Facility in the Westmorland/Albert Region has been under study since August 1988. A number of studies have been conducted to date and serve as background to this EIA. These include:

- *Waste Audit*
- *Waste Management Alternatives*
- *Overview of Waste Management in Westmorland/Albert*
- *Site Selection Criteria Scoring System*
- *Westmorland/Albert Public Attitude Study*
- *Constraint Mapping for Preliminary Site Identification*
- *Site Selection Report*
- *Collection and Transportation Analysis*
- *Assessment of Landfill Leachate Treatment Options*

Components of these studies are included in the text of this report, and summaries of some are bound in Appendix B.

1.2.2 PROJECT RATIONALE

After two full years of investigation, members of the Committee made their decision on the most applicable method of solid waste management in the two counties. The technical data obtained from the "Waste Audit" and "Waste Management Alternatives" reports, as well as the information received through many public consultations, enabled the Provisional Committee to select a Waste Management Strategy which includes a combination of waste reduction and disposal technologies. The new strategy will ensure that the Region's waste will be disposed of in the most economical and socially acceptable manner while protecting the environment. To achieve this, the Committee decided that an Integrated Waste Management Facility for the Region should be established.

TABLE 1-1

Existing Sites for the Disposal of Municipal Waste

Site	Operator
Alma	Village of Alma
Berry Mills	D.O.T.
Cap Pelé	Village of Cap Pelé
Dorchester	Village of Dorchester
Elgin	D.O.T.
Halls Hill	D.O.T.
Hillsborough	Village of Hillsborough
La Hetrière	D.O.T.
Moncton	City of Moncton
Petitcodiac	Village of Petitcodiac
Port Elgin	Village of Port Elgin
Riverside-Albert	Village of Riverside-Albert
Riverview	Town of Riverview
Sackville	Town of Sackville
Salisbury	Village of Salisbury
Scoudouc Industrial Park	D.S.S.
Shediac	Town of Shediac
Turtle Creek	D.O.T.

1.2.3 COMPONENTS OF THE WASTE MANAGEMENT STRATEGY

Initially the main component of the Integrated Waste Management Facility will be a sanitary landfill. A sanitary landfill is a controlled access facility where solid waste is received and disposed of under full-time supervision. An integral part of a sanitary landfill is the environmental protection systems which are installed prior to the site going into operation and the on-going monitoring of these systems to minimize negative effects caused by the operation. Proper design requires that the waste be contained and that any effluent (leachate or runoff) be collected and treated prior to discharge to a receiving stream. The proposed sanitary landfill was required to have the capacity to dispose of the waste generated by the two counties for at least the next 25 years. However, the sites identified are of much greater capacity. Assuming the quantity of waste generated were to remain constant over the next 25 years, the Delong Drive Site has a life expectancy of approximately 70 years, while the Berry Mills Road Site and Route 126 Site have life expectancies of approximately 110 years and 122 years, respectively.

Other major components of the Waste Management Strategy include a schedule to divert 30% of the Region's waste from the landfill by the year 1995, and 50% by the year 2000. In order to meet these diversion targets, education programs to promote reduction in waste generation, recycling programs, and composting operations will have to be implemented. Central recycling and composting facilities alone would be able to divert in excess of 50% from landfill. If these targets set by the Committee are achieved, the landfill will have a considerably longer lifespan.

1.2.4 SITE SELECTION PROCESS

The selection of the most suitable site for the Integrated Solid Waste Management Facility was carried out using established siting guidelines and site selection criteria. In order to focus the site selection process, it was decided by the Committee to initially limit the study area to a 15 km radius circle around the Greater Moncton Area. The fact that this area is the "centroid" of waste generation for the Region assured that transportation costs would be minimized. If an acceptable site could not be identified therein, the circle would be expanded until a site is found.

In the preliminary stages of the site selection process, "Constraint Mapping" was performed to designate portions of the study area which were unacceptable for landfill placement. The following constraints were incorporated in the exercise: public parks and steep slopes, airports and Department of National Defence properties, geological conditions, rivers and lakes, streams, primary and secondary roads, and commercial, industrial and residential properties including appropriate set-back areas. At this time, a site selection scoring system was also developed for future use in comparing potential sites.

The "Constraint Mapping" process, a review of all land not constrained out, a call for proposals for provision of land, and preliminary site investigation reduced the number of potential sites to four. The preliminary site investigation included aerial reconnaissance, subsequent walk-over surveys, and a test pit program, which provided a review of soil types, overburden thickness and groundwater conditions. Using data available at the time, the site selection scoring system previously developed was applied to each of the remaining sites. This system consisted of assessing each individual site and allotting points based on the following objectives and criteria: area planning and development, ecological considerations, physical site considerations, public acceptability, and public health and safety. Through application of this system, one of the four sites was dropped because of its relatively low score and because the site was found to be less suitable than others on an ecological basis (the site was too close in proximity to the Dobson Trail, a popular recreational area for a wide variety of outdoor activities and contained a number of wet areas and bog lands).

The three remaining potential sites are labelled as follows: Delong Drive Site, Berry Mills Road Site, and Route 126 Site. All three sites are subject to the EIA process. All three sites were considered suitable at the initiation of the EIA process.

A detailed subsurface investigation was then carried out at these remaining three sites. The investigation consisted of a series of boreholes through the overburden and into rock at each site. Sampling was conducted from the boreholes for laboratory examination and testing of representative samples. Two standpipe piezometers were installed at each borehole location to allow groundwater monitoring in the bedrock and overburden. Complete details and results of the soils investigation are presented in the Site Selection Report, ACI File 2771-4.3 dated January, 1991. A summation of the findings are also discussed in Section 2.3 of this report and boring logs are found in Appendix C.

1.3 Conduct of the Study

A baseline of information on particular aspects of the environment at each site is required for the EIA. Specifically, information is developed on the geology, hydrogeology and groundwater, surface watercourses, terrestrial and aquatic biology and a socio-economic profile of the region.

1.3.1 GEOLOGY, HYDROGEOLOGY AND GROUNDWATER

A detailed review of the geological/hydrogeological setting for the three individual sites was carried out to supplement the information found in the subsurface investigation carried out during the site selection phase.

The results of a literature review (geological maps and reports), combined with linears identified using remote sensing techniques, such as airborne geophysical surveys and satellite imagery, provided the basis for the design of a ground geophysical survey. This survey was carried out using VLF electromagnetic methods. Evaluation of groundwater flow direction and gradients was given emphasis, as was the identification of potential zones of high secondary permeabilities in the bedrock.

Areas for test drilling were identified from the geophysical survey. Three boreholes were completed on each site with double piezometers constructed. Specifics related to geology, groundwater flow, recharge/discharge conditions and water quality were obtained from the boreholes.

1.3.2 SURFACE WATERCOURSES AND TERRESTRIAL BIOLOGY

Reconnaissance visits to the three potential sites were conducted in December of 1990 and April of 1991. During these walking surveys, sampling stations were selected for watercourses applicable to each site and quantitative forestry data was collected in order to describe the terrestrial biology of each site.

Watercourses adjacent to the Delong Drive Site include Jonathan Creek and Michael's Creek. Four sampling stations were established on Jonathan Creek, while five stations were selected for Michael's Creek.

With respect to the Berry Mills Road Site, watercourses of importance include Somers Creek and Jonathan Creek. Five sampling stations were selected on Somers Creek. Sampling stations for Jonathan Creek are the same as those selected for the Delong Drive Site.

Watercourses of importance to the Route 126 Site are the Cocagne River and Shaw Brook. Two sampling stations were established on each of the watercourses.

A description of the variation in the forest stand on all three sites and an assessment of the potential as deer and moose wintering areas were generally established through the walking surveys. More detailed data was obtained through the selection of sample plots representing non clear cut areas at each of the three sites. In these plots, the number of trees, the species, the stand condition, the crown closure, as well as the diameter and breast height of individual trees were determined. This information also served in obtaining a standard index of the stand types relating to deer or moose wintering areas.

1.3.3 AQUATIC BIOLOGY

Aquatic resources downstream of a proposed waste management facility are considered to be important fisheries resources. For this reason, a review of fish habitat was done and benthic invertebrate populations were determined.

The review of brook trout habitat and salmon habitat in watercourses adjacent to sites were based on water quality considerations and personal communications with New Brunswick Department of the Environment officials and Department of Fisheries and Oceans officials. Information on salmonoid habitat in Jonathan Creek, Somers Creek and the Cocagne River was also gained by means of electrofishing spot checks. Electrofishing spot checks were done on the Cocagne River in April of 1991 and on Jonathan and Somers Creeks in September 1991.

Any fish removed for measurement were done so by using discrete "sweeps" with electrofishing gear. Three such sweeps were done from the upstream end to the downstream end. The number of fish captured in each successive non-overlapping sweep were recorded according to species and size (length).

Finally, in order to determine where potential salmonoid food was available, benthic invertebrates were sampled on Jonathan Creek, Somers Creek and the Cocagne River. Qualitative sampling was done on a presence/absence basis using a modified kick sampler at five locations along 30-40 m sections of stream.

1.3.4 COLLECTION OF SOCIO-ECONOMIC DATA

Socio-economic data was obtained by consulting published information on the Region, as well as information contained in a previous study on the siting of the solid waste management facility in the Region. Other documents on landfilling and their socio-economic impacts were also consulted.

Visits to the three potential sites were made to gain first-hand knowledge of land uses adjacent to the sites. Also, the proposed haul routes were driven to gain a better understanding of potential impacts.

Interviews with local and regional officials as well as private individuals were made to augment published information already in hand. Government departments were also consulted. Documents and persons contacted to obtain socio-economic background are listed in the Sections entitled References and Personal Communications.

1.3.5 PUBLIC MEETINGS

Public meetings have been held by the Committee since commencement in 1988 of the process of finding an acceptable solution to the region's solid waste problems. Meetings were held across the region to discuss the waste audit and waste management alternatives before the Committee reached its "decision". Presentations were made to all municipal councils and any service club or community group who was interested. Public information sessions were conducted in four areas by the Consultants to identify areas the Committee was interested in after completion of the constraint mapping process, and to obtain public input on the selection of these areas. A further round of public meetings, following release of the Site Selection Report, were held at the Université de Moncton on Monday, January 28th, 1991; at the Magnetic Hill School on Tuesday, January 29th, 1991; and at the Dr. Bernice L. MacNaughton High School on Wednesday, January 30th, 1991. A total of 7 sessions were involved in these meetings and they were attended by a total of 172 people.

These sessions consisted of a 15 minute presentation by Committee Chairman, Armand Banniser, followed by a 20 minute presentation by Acadia Consultants and Inspectors (ACI).

After the presentation, the public was invited to direct their concerns, comments and questions, technical and general, to committee members or to the consultant.

The concerns, comments and questions recurring most often at these meetings include the following:

- *What will be done with wastes not accepted for landfilling?*
- *Will household hazardous wastes and medical wastes be accepted?*
- *What will be the impact on the wells near the site?*
- *Will recycling initiatives be taken?*
- *How will this facility affect property values near the site?*
- *Who will control what is dumped at the site?*
- *Will there be a problem with seagulls?*
- *Will leachate be collected?*

- *How long will the site last?*
- *Are there dangers involved, for example, the runoff into Jonathan Creek, Somers Creek or the Cocagne River?*
- *How many people would be employed at the site?*
- *Are the rural areas to receive weekly pickup?*
- *Is there any consideration given to garbage workers - safety, job security?*
- *Will there be a noise or smell?*
- *Will the site include an incineration plant?*
- *Who will operate the site?*
- *How can we trust government to ensure the site is operated properly?*
- *District 15 School Board considers Route 126 a "hazardous route"; therefore, they are presently bussing children over this route? Did you consider this?*
- *What would be the extent of groundwater contamination if the liner leaks?*
- *Is there any limitation on the use of the site after it is closed?*
- *What are costs?*
- *What about composting at the site?*

All of the above concerns, and others, are addressed in this report.

1.3.6 ASSESSMENT OF IMPACTS

Every solid waste management method or technology, such as an Integrated Waste Management Facility involving a sanitary landfill, has a certain level of risk associated with it. In fact, no such project can proceed without having some effects on the surrounding biological, physical, human and socio-economic environment. Most people intuitively recognize the most common and dramatic risks, such as the possibility that groundwater will become contaminated, the increase in local traffic due to the trucking of wastes to the site, etc. For example, an increase in traffic which significantly decreased the safety rating of a highway or street, would be considered an impact. Significant impacts are of concern; the EIA report identifies and examines impacts and makes conclusions about their significance and mitigation measures required.

In order to identify what the public perceptions of impacts from the proposed Westmorland/Albert Integrated Waste Management Facility were, public meetings were held (identified in Section 1.3.5). Also, a list of project actions was compared to a list of environmental components to produce a matrix of interactions. This was completed for all three potential sites. Initially, the interactions were only separated into four groups: those with no effect, those where the effect is seen to be minimal, those where there are potential impacts, and those where there is an impact. The two last groups were then considered in more detail, and an estimate of the likelihood of a serious consequence was made. Mitigative measures were proposed and any residual effects were considered.

Although there is often uncertainty in the prediction of impacts, the degree of uncertainty is identified where possible. Where sensitive resources are present, monitoring programs are proposed to provide an early warning of impact if it occurs. Remedial action will then be taken as soon as the impact is identified.

2.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

2.1 Study Boundaries

2.1.1 TEMPORAL

Temporal bounds for the project are established in three time frames: construction, operation, and post-closure. Duration for each of these phases is determined and used as temporal bounds. The landfill component of the Integrated Waste Management Facility is expected to operate for a minimum of 25 years. However, ongoing monitoring of the landfill location will be for a considerably longer term, perhaps for up to 50 years from closure.

2.1.2 SPATIAL

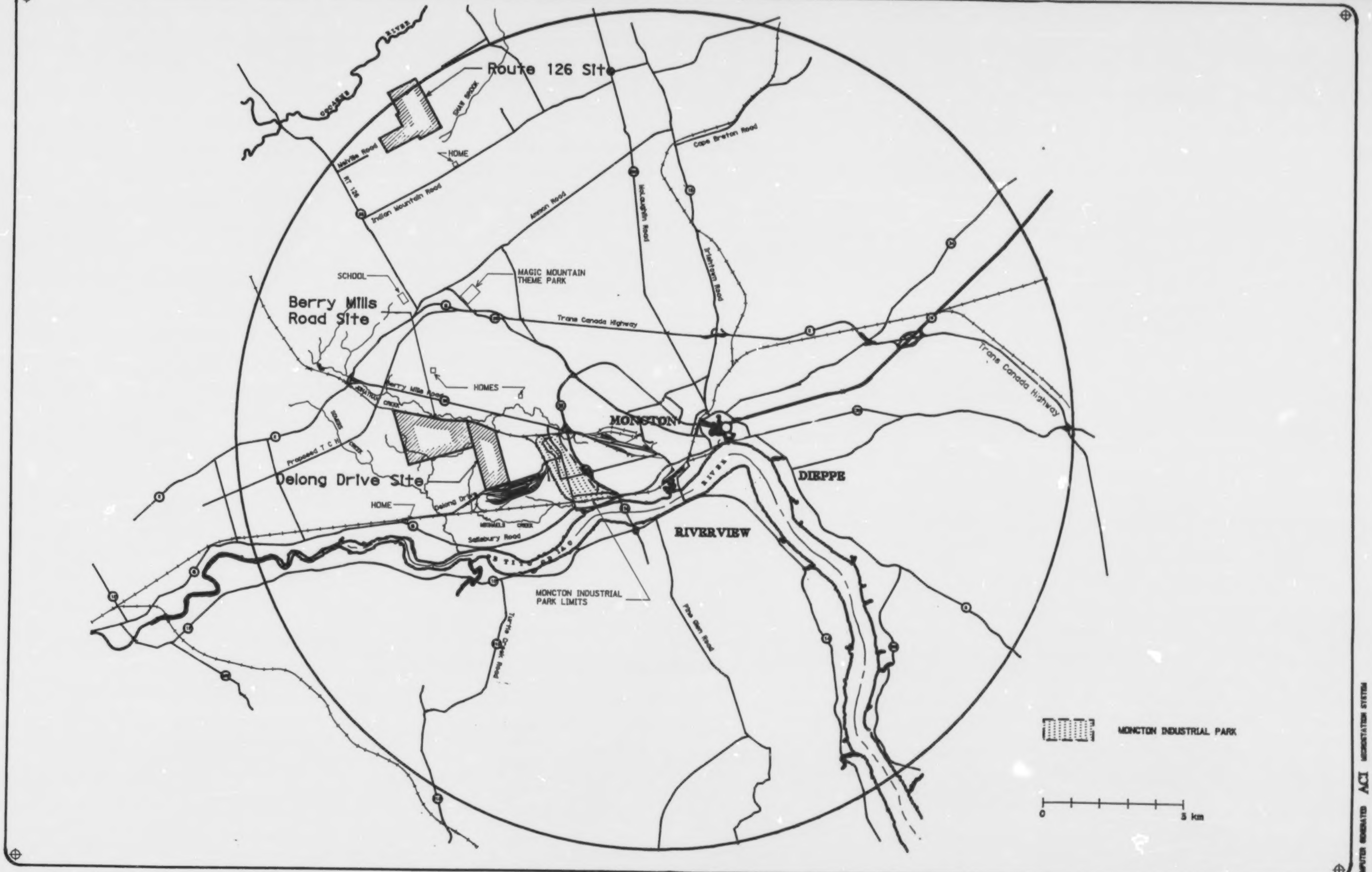
For the socio-economic aspects, the spatial bounds focus on the economic activity generated by the project, as well as the services and facilities available within the immediate area. Spatial bounds for the physical and biological assessment consist of the immediate surroundings of the proposed waste management facility. As previously stated, there are three potential sites for the proposed facility. Locations of the sites, as well as other details, are shown in Exhibit 2-1. Details on the extent of the City water distribution system are found in Drawing 1 (Appendix D). The sites are described as follows:

Delong Drive Site ·

Land available at this site totals approximately 212 ha. After constraints are applied, the area available for actual landfill development is equal to 104 ha.

This site is situated off of Delong Drive, north of the CNR Humpyard. It is bordered to the north by a CNR line, to the south by Delong Drive and to the east and west by private property. It is located approximately 2.7 km along Delong Drive from Edinburgh Drive. Surface drainage is generally to the south towards Michael's Creek, a tributary of the Petitcodiac River, with the exception of the northern corner of the site which drains to Jonathan Creek, also a tributary of the Petitcodiac River.

There are no residential developments in the direct vicinity of the site. The nearest residence is located approximately 1.1 km from the site and is situated at the corner of Horsman Road and Old Ryan Road, north of the Berry Mills Road. The closest residence on Delong Drive is located approximately 3.9 km to the west of the site where Delong Drive meets with Salisbury Road (Route 106). The site is not visible from residences or major thoroughfares within 4 km.


Route 126 Site
OCCAPEE RIVER
SHAW BROOK
Melville Road
HOME
RT 126
Indian Mountain Road
Ammon Road
McLaughlin Road
Cape Breton Road
Irishtown Road
SCHOOL
MAGIC MOUNTAIN
THEME PARK
Berry Mills
Road Site
Trans Canada Highway
Berry Mills Road
JONATHAN CREEK
HOMES
SOMERS CREEK
Proposed T C H
MONCTON
Delong Drive Site
HOME
Delong Drive
MICHAELS CREEK
Salisbury Road
PETITCODIAC
RIVER
DIEPPE
RIVERVIEW
MONCTON INDUSTRIAL
PARK LIMITS
Turtle Creek Road
Pine Glen Road
Trans Canada Highway
MONCTON INDUSTRIAL PARK
0
5 km

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No.	Revision	Chd.By	Date

Drn. By	K.A.M.
Dsg. Chd. By	H.B.C.
Calcs. By	
Calcs. Chd. By	
Date Drn.	APR 1991
Date Issued	
Auth. By	

Const. North

Project Title

WESTMORLAND / ALBERT INTEGRATED
SOLID WASTE MANAGEMENT FACILITY
ENVIRONMENTAL IMPACT ASSESSMENT

Dwg. Title

PROPOSED SITES

Project	2771 - 4.7
Dwg.	EXHIBIT 2.1
Scale	1: 125000
Rev. No.	0

COMPUTER GENERATED ACI MICROSTATION SYSTEM

At its closest point, the site is approximately 1.5 km west of the Moncton Industrial Park. The Industrial Park area is zoned Restricted Industry which extends to border the CNR line north of the site.

The site is located approximately 6 km from the centre of the Greater Moncton Area (Downtown Moncton). It is entirely within the Moncton city limits.

Berry Mills Road Site

Land identified at this site totals approximately 324 ha. After constraints are applied, the area available for landfill development is equal to 136 ha.

This site is located south of the Berry Mills Road approximately 4 km east of Edinburgh Drive. The site is bordered to the north by a CNR line, to the east by Moncton city limits, to the west by private property, and to the south by a NBEPC easement. Surface drainage is primarily to the south towards a branch of Somers Creek, a tributary of the Petitcodiac River, except for along the CNR line which drains to Jonathan Creek.

There are no residential developments in the immediate area of the site. The nearest residence is located approximately 1.4 km from the site and is situated to the north on the Zack Road, which is north of the Berry Mills Road. The site is not visible from residences or major thoroughfares within 4 km.

The site is located approximately 2.5 km from the Moncton Industrial Park and 9 km from the centre of the Greater Moncton Area (Downtown Moncton).

Route 126 Site

Land identified at this site totals approximately 280 ha. After constraints are applied, the area available for landfill development is equal to 170 ha.

This site is located approximately 1.6 km north of Indian Mountain Road and 1.8 km east of Route 126. Surface drainage is generally to the northwest towards small unnamed tributaries of the Cocagne River, except for a small section of the site at the southern end which drains to Shaw Brook, again a tributary of the Cocagne River.

There are no residential developments in the direct vicinity of the site. The closest residence is situated approximately 1.6 km from the site on the Indian Mountain Road. Part of the site is visible (distance over 1.6 km) from some residences along Indian Mountain Road and from certain areas along Indian Mountain Road. The site could be developed with berms to restrict this visibility.

There are no industrial developments in the direct vicinity of the site. The site is located approximately 8 km from the Magic Mountain Theme Park, which is a major tourist attraction of the Moncton Area, and approximately 15 km from the centre of the Greater Moncton Area (Downtown Moncton).

2.2 Geological/Hydrogeological Setting

The geological conditions are of primary importance on a site specific basis, but should be considered within the context of the regional geological environment. For this reason a review of the regional geological setting has been prepared. The geological conditions specific to each site are then discussed on an individual basis.

The information presented was compiled from published and unpublished reports and maps available from the New Brunswick Department of Natural Resources, including assessment file reports, the New Brunswick Department of the Environment, the Geological Survey of Canada and in-house files. Data obtained during the site selection process was also used.

2.2.1 BEDROCK AND SURFICIAL GEOLOGY

The bedrock geology in the Moncton area can be subdivided into two major units. Older rocks of the Kingston Uplift occur in the Lutes Mountain - Indian Mountain areas to the northwest of Moncton. The lowland areas to the north and south of the Kingston Uplift are underlain by younger rocks which are of Carboniferous age (250 to 300 million years) on the geological time scale (Exhibit 2-2).

The Kingston Uplift (Exhibit 2-2), is a dominating topographic feature situated northwest of Moncton and is comprised of metavolcanic and metasedimentary rocks of pre-Carboniferous age. Major regional northeasterly trending fault structures which extend from southern New Brunswick to Prince Edward Island occur within, and form the boundaries of the unit (Exhibit 2-2). Movement of these regional fault structures in the geological past has resulted in the older rocks of the Kingston Uplift being raised to their present position and the younger overlying rocks have subsequently been eroded. The Smith Creek Fault and the Berry Mills Fault define the northern and southern limits of the unit.

The Carboniferous rock units are situated to the north and south of the Kingston Uplift. These rocks are typically flat-lying sedimentary rocks including non-marine sandstones, claystones, and conglomerates. Colour ranges from red to grey to brown.

On the northern side of the Kingston Uplift, the Carboniferous rocks are part of the Pictou Group. A narrow band of sightly older rocks occurs on the flank of the Uplift. This is identified

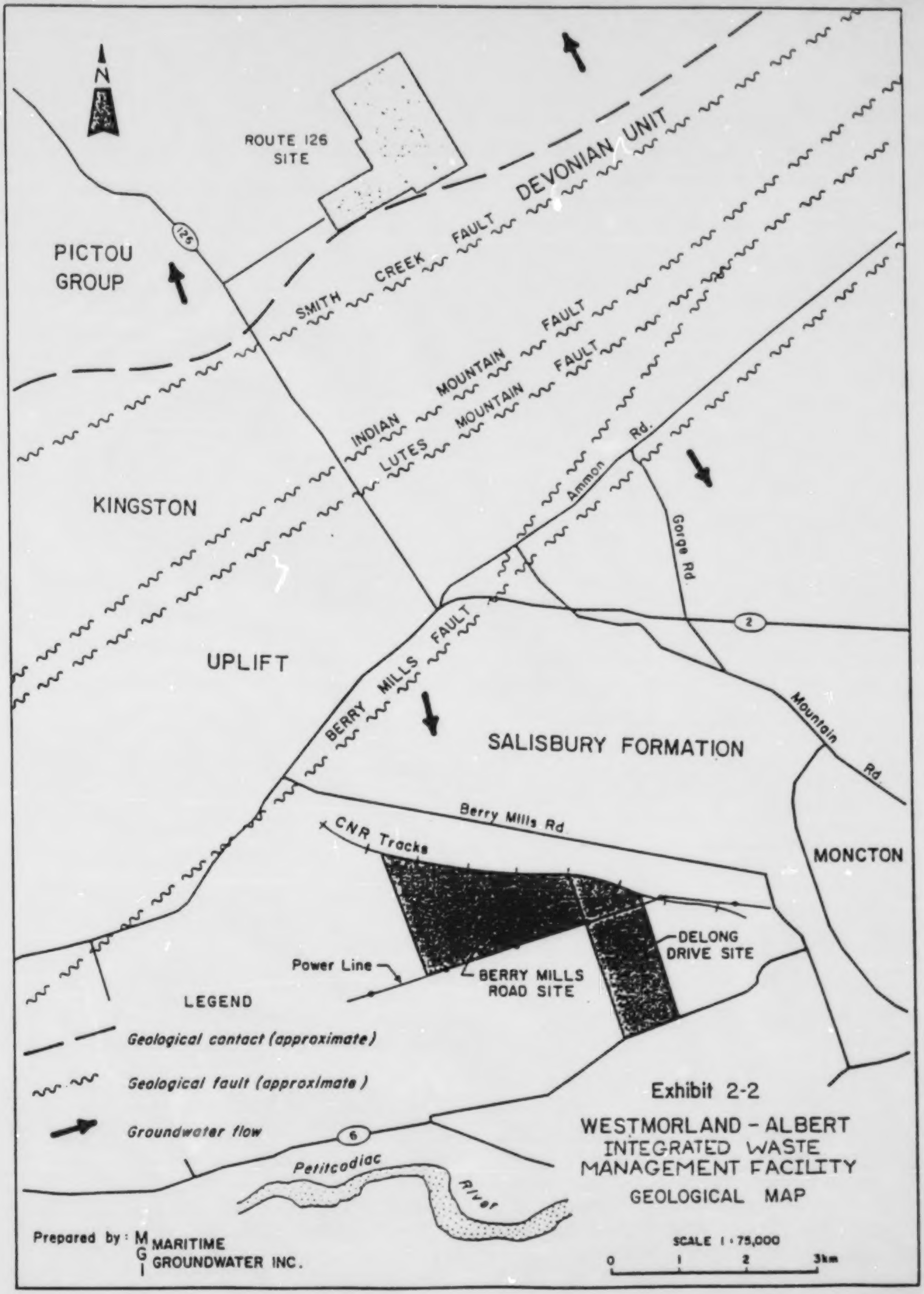

N
ROUTE 126
SITE
DEVONIAN UNIT
PICTOU
GROUP
126
SMITH CREEK FAULT
INDIAN MOUNTAIN FAULT
LUTES MOUNTAIN FAULT
KINGSTON
UPLIFT
Ammon Rd.
Gorge Rd.
2
BERRY MILLS FAULT
SALISBURY FORMATION
Mountain Rd.
Berry Mills Rd
CNR Tracks
MONCTON
DELONG
DRIVE SITE
Power Line
BERRY MILLS
ROAD SITE
LEGEND
Geological contact (approximate)
Geological fault (approximate)
Groundwater flow
6
Petitcodiac
River
Prepared by: MGI MARITIME GROUNDWATER INC.
SCALE 1 : 75,000
0
1
2
3km

Exhibit 2-2

WESTMORLAND - ALBERT
INTEGRATED WASTE
MANAGEMENT FACILITY
GEOLOGICAL MAP

as the Devonian unit on Exhibit 2-2 and is assigned an Upper Devonian to Carboniferous age on the geological time scale. These rocks show a moderate degree of deformation which may be a reflection of their position relative to the Smith Creek Fault.

On the southern side of the Kingston Uplift, the Carboniferous rocks are also part of the Pictou Group. The Delong Drive and Berry Mills Road sites both are underlain by rocks of the Salisbury Formation, a subdivision of the Pictou Group. In general, this unit is comprised of red and, to a lesser extent, grey claystone and siltstone with lesser amounts of sandstone and conglomerate which were deposited in a braided fluvial environment. The Salisbury Formation can have a thickness in excess of 1100 feet, and stratigraphically overlies the sandstone and conglomerate of the Boss Point Formation. The Salisbury Formation grades into another subdivision of the Pictou Group, the Richibucto Formation, to the east of the study area.

The surficial deposits in the Moncton area consist primarily of a lodgement till which was deposited by glacial action. This till typically is 1 to 8 metres in thickness but greater depths occur at the base of the Kingston Uplift and in the Petitcodiac River valley. Most of the tills are generally of a reddish hue, and consist of silty sands or sandy silts, with a variable component of clay. This reflects the composition of the underlying bedrock.

Localized glaciofluvial deposits are known to occur in the Moncton area and consist mainly of gravel and sands. Deposits of marine sands and clays also occur locally in the Moncton area. These deposits are the result of marine incursion, due to isostatic readjustment caused by glacial retreat.

The topography and physiography of the Moncton area reflects the bedrock geology. Ridges associated with the Kingston Uplift rise 200 metres above sea level. The lowland areas underlain by the Carboniferous rock units are characterized by gently rolling valleys with associated ridges.

2.2.2 HYDROGEOLOGICAL BACKGROUND

The available data on the regional hydrogeological environment indicates that the Kingston Uplift represents a groundwater divide. To the north of the Uplift the regional groundwater flow direction is to the northwest whereas to the south the regional flow is to the south and southeast (Exhibit 2-2). The topographic high associated with the Kingston Uplift represents a recharge area (i.e. downward hydraulic gradient).

Flowing artesian wells are known in the Moncton area in the vicinity of the Gorge Road, the Ryan Road, and Magnetic Hill. These indicate areas of discharge or an upward groundwater gradient.

The permeability of the rock can be classified as primary or secondary. The primary permeability is dependent on the initial depositional porosity of the rock, whereas the secondary permeability is dependent on the porosity developed after the initial formation of the rock, such as fault or fracture related porosity. The wide range of permeabilities noted in the area is due to the presence or absence of geological faults and/or fracture zones within the sedimentary rocks (the secondary permeability).

Groundwater flow within the Salisbury Formation upper bedrock unit is generally to the south-southeast, reflecting the regional topographic gradient towards the Petitcodiac River. Available information on aquifer parameters indicates a low to moderate permeability with a hydraulic conductivity ranging from 15 to 150 meters/year, with fracture flow contributing a significant effect. Pump tests which were conducted in similar geological conditions, within a few miles of the Berry Mills Road Site and the Delong Drive Site, produced storage coefficient results in the order of 1×10^{-3} to 1×10^{-4}, indicating that the aquifer is under confined or partially confined conditions. The overlying dense glacial tills provide the upper confining strata.

The Salisbury Formation varies from a good to a poor aquifer (in terms of water well production) throughout the region, but is generally poor in the Moncton area. Past pump test analysis (Carr, 1968) has shown that the Salisbury Formation is variable in hydraulic properties. This variability is due to the presence or absence of fractures in the bedrock which controls the hydraulic conductivities.

Carr (1968) found that there appears to be a low transmissibility zone within the Salisbury which extends from the southwest to the northeast across the Moncton City area.

On a regional scale, potable water for residential purposes is supplied from bedrock aquifers with an average yield of 1.5 litres per second (Carr, 1968). Carr notes a range of 0.75 to 11.3 litres per second (10 to 150 gpm) with the high yields indicated to be in the Shediac area. Larger yield wells are also known to occur in the McLaughlin Road (Reservoir) area. The stated average was consistent with other sources including the well driller records at NBDOE, discussions with local well drillers, and in-house data. In most cases quantities were based on estimates rather than actual test data. The till aquifer has considerably lower yields and is not used as a major supply of water.

Chemically, the groundwater in the Moncton area is classed as either a sodium bicarbonate or calcium bicarbonate water of excellent quality for human consumption. Total dissolved solids average less than 400 parts per million, but above average concentrations of fluoride, iron and manganese have been noted in the study area.

2.2.3 INVESTIGATION OF INDIVIDUAL SITES

Assessment of the three individual sites in the course of the present study was conducted to augment existing geological and hydrogeological data. Additional information acquired during the site selection process was also incorporated into the data base. Evaluation of groundwater flow directions and gradients was given emphasis, as was the identification of potential zones of high secondary permeabilities in the bedrock.

The surficial deposits underlying the study areas were generally of low permeability. In addition, the proposed design of the landfill is intended to minimize surface water entry into the overburden material. The bedrock underlying the study sites also has generally low primary permeability. However, zones of higher secondary permeability in the bedrock, such as would result from fracturing or faulting of the rock, could occur. Since such features should be considered in the overall design of the facility and in the design of the monitoring program, the hydrogeological investigations concentrated on the identification of potential zones of secondary permeability.

The data available from the literature review, particularly geological maps and reports, formed the initial basis for identification of relevant bedrock structures. However, much of the available data was of a regional nature which did not provide adequate detail on a site specific basis. Furthermore, exposures of bedrock in the study areas are relatively infrequent and represented a limitation to the use of geological mapping to delineate potential zones of high permeability. On this basis several indirect methods were used as data sources to assist in the identification process.

Airborne geophysical surveys are one method of remote sensing which have proven applications in the identification of geological structures. Applicable survey data obtained in the course of this study included an airborne electromagnetic survey flown for Canadian Nickel Co. Ltd. in 1982 and airborne magnetic surveys flown for the Geological Survey of Canada in 1950 and 1958.

Satellite imagery was another remote sensing technique used to further identify potential targets. Existing Landsat TM imagery was evaluated in the course of the study and used to identify structures of interest. Landsat TM satellite imagery incorporates seven spectral bands including two shortwave infrared, one near infrared, one thermal infrared, and one from each of the blue, green and red spectrums. Various features on the surface of the earth give a characteristic spectral response (or signature) based on the illumination received from the sun. This spectral response is recorded by a sensor carried on a satellite. The data is then transmitted to earth, processed using computer techniques, and analyzed.

Both the airborne geophysics and the satellite imagery identified features of interest to the present study and these are reviewed in the discussion of each individual site. These techniques, however, have some limitations as to the accuracy of defining the ground position of a particular feature. On this basis ground geophysics was conducted to supplement the data obtained from remote sensing. A VLF (very low frequency) electromagnetic survey was conducted using a Geonics EM-16 instrument.

The ground geophysical survey was designed in a manner which provided optimum coverage for the delineation of northeasterly trending structures (i.e. the regional trend). The survey lines were placed perpendicular to the anticipated structural trend to facilitate the identification and correlation of "conductors" across more than one line. The survey was intended to closely define the ground position of features outlined by other techniques as well as identify additional structures. The transmitter station selected for the survey was a marine navigational station located at Cutler, Maine. The signal from the transmitter (i.e. the primary field) was used as a reference or a datum and the receiver unit measured secondary fields from electrical currents within the bedrock. This technique is used principally for detection of sulphide zones, etc. in mineral exploration but will also delineate features such as water filled bedrock faults or fracture zones which represent electromagnetic conductors. In areas of habitation and industrial development, interference (i.e. due to power lines, fences, etc.) can occur and must be considered in the interpretation of the data. At each field station, an in-phase and quadrature reading was obtained. Fraser filtering of the recorded data was then completed to facilitate interpretation.

The geophysical lines were located in the field by means of a hand-held compass. Each line was established on a predetermined bearing and was "tied" to identifiable topographic or cultural features (e.g., railway tracks, power lines, roads) to assist in the plotting of line locations. Field work was conducted in early April. A melting snow layer in excess of one metre in thickness necessitated the use of snowshoes by field personnel. Distances along each survey line was established using a hip-chain. This instrument measures distances by means of a disposable, biodegradable thread which is reeled through a distance recorder. Survey "stations" for geophysical readings were established at 25 m intervals along each line. Approximately 184 stations were established at the Delong Drive Site, 260 stations at the Berry Mills Road Site, and 198 stations at the Route 126 Site. The survey lines were established in a manner which provided a reasonable level of coverage across the full extent of each of the sites.

Indirect methods provide valuable data for the identification of potential zones of high permeability. However, these methods will not verify the nature of the structures or the associated level of permeability. This must be accomplished by construction and testing of test holes. The indirect methods provide viable targets for a drilling program and permit a high level of data acquisition with a minimum number of test holes. The remote sensing techniques identified numerous features which were primarily oriented in a northeasterly direction and conformed to regional geological trends. Ground geophysics was used to verify locations of northeasterly trending structures. These structures were target areas for the drilling program.

Three locations at each proposed landfill site were selected for the drilling program. The test drilling locations were intended to investigate features which had been identified by the remote sensing and ground geophysics programs. The drilling technique used for this project involved the use of a tricone bit which produced "chips" of rock on which the identification of rock type was based. The drilling technique did not permit the determination of orientation and/or dip for bedding planes or fractures. A shallow and a deep well were constructed at each location. Depths of 7.6 metres and 22.8 metres respectively were used for the shallow and deep wells at two locations and depths of 22.8 metres and 45.7 metres were used for the third location. The program was primarily intended to assess bedrock permeability since previous studies had indicated low hydraulic conductivity values for the till overlying the bedrock.

Drilling of the test holes was completed by a tracked-mounted (muskeg) drill due to the difficult access to the sites. Exhibit 2-3 shows the typical well construction used at each location. The shallow hole at each location was drilled by triconing or augering a 150 mm diameter hole through overburden and into bedrock. A casing was seated and sealed at this point. The hole was then completed by triconing at a 100 mm diameter until the full depth was reached. The deep hole at each location was also triconed or augered at 150 mm diameter through overburden and into bedrock, until the hole was three metres or more below the depth of the shallow hole (Exhibit 2-3). A casing was seated and sealed into bedrock at this point. This procedure resulted in the deep hole being cased to a depth greater than the shallow hole. The hole was then completed by triconing at 100 mm diameter until the final depth was reached. Borehole logs from the drilling program are included in Appendix C1.

After completion of the test hole drilling program, groundwater levels were measured in order to determine the groundwater flow

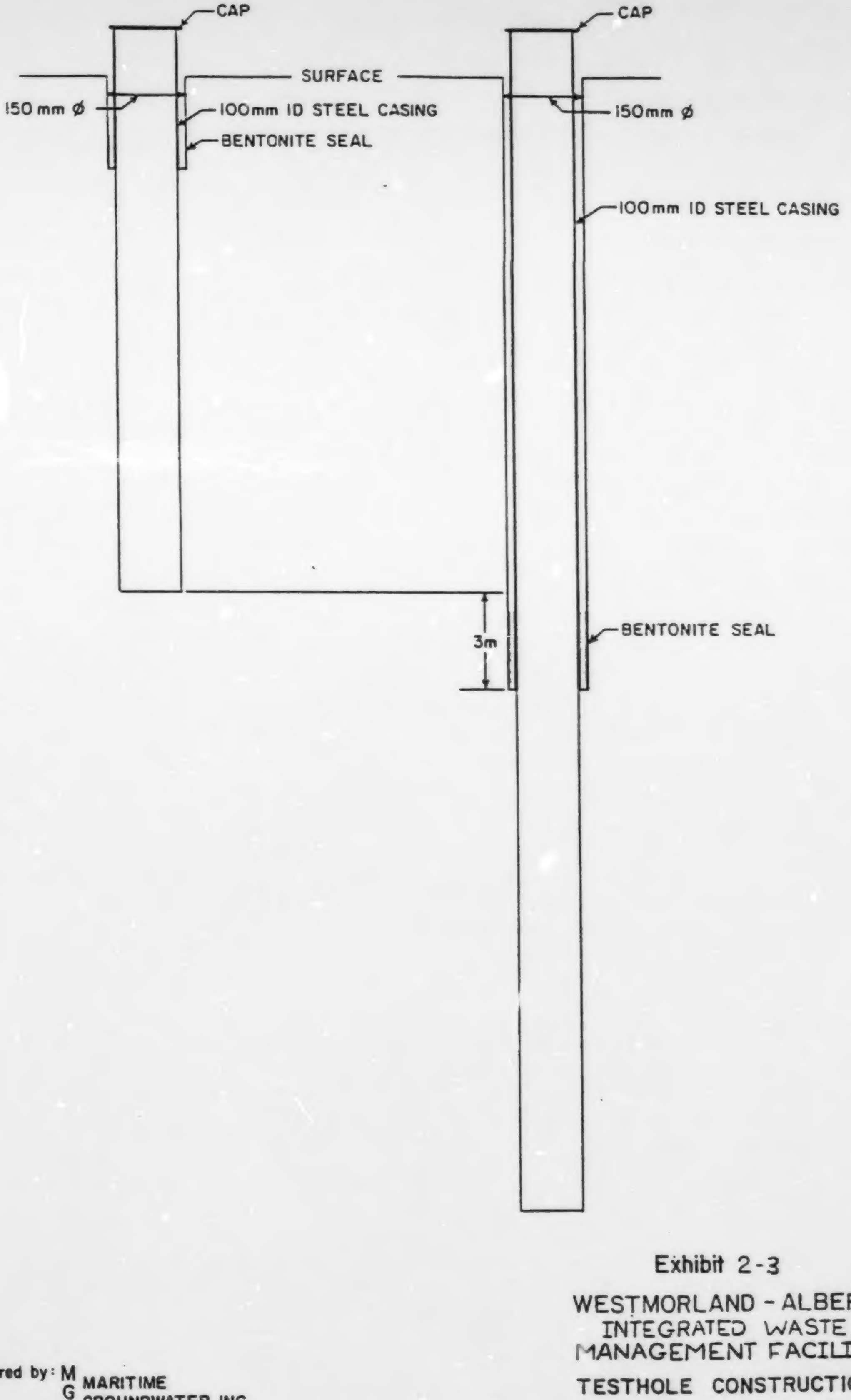

CAP
CAP
SURFACE
150 mm Ø
100mm ID STEEL CASING
BENTONITE SEAL
150mm Ø
100mm ID STEEL CASING
3m
BENTONITE SEAL

Exhibit 2-3

WESTMORLAND - ALBERT
INTEGRATED WASTE
MANAGEMENT FACILITY

TESTHOLE CONSTRUCTION

Prepared by: MGI MARITIME GROUNDWATER INC.

direction at each of the proposed landfill sites. In addition, permeability tests were conducted on each test hole.

Delong Drive Site

The proposed Delong Drive site is situated in an area of flat to gently rolling topography. Elevations range from 40 to 60 metres above sea level. A topographic ridge is located along the power lines in the northern section of the site and represents a topographic divide. Surface topography slopes in a northeasterly direction at a gradient of 2.1% in the northernmost part of the site. On the south side of the topographic ridge the surface topography slopes in a southerly direction at an average gradient of 2.4%. The southernmost section of the site is relatively flat lying, with a gradient of 0.6% to the southwest.

Several features which represented potential zones of high permeability were identified at the site (Exhibit 2-4). Airborne geophysical surveys from previous studies indicated the presence of a strong northeasterly trending conductor (anomaly D-1) in the northwestern corner of the site (Exhibit 2-4). However the survey did not cover the entire site and other structures were not identified. Satellite imagery indicated the presence of two northeasterly trending lineaments (anomalies D-2 and D-3), and two northwesterly trending lineaments (anomalies D-4 and D-5). The ground geophysical survey detected five moderate to strong ground geophysical conductors (D-6 to D-10). Geophysical conductor D-6 was interpreted to represent the ground position of a regional structure associated with an airborne conductor (D-1) and a remote sensing linear (D-2). Geophysical conductors D-7 and D-8 are located near, and are parallel to anomaly D-6 and are interpreted as possible subsidiary features associated with anomaly D-6. Geophysical conductor D-9 was correlated with a remote sensing linear (D-3). Geophysical conductor D-10 was interpreted to represent the surface trace of a basement (i.e. buried pre-Carboniferous) structure (anomaly D-11) which was identified in a aeromagnetic investigation of the Moncton Basin. Post-Carboniferous movement along the plane of weakness associated with the basement structure would result in the surface expression of this feature. The northwesterly trending remote sensing linears D-4 and D-5 were interpreted to represent possible secondary structures related to the regional northeasterly trend of geological structures in the Moncton area. The junction of northwesterly and northeasterly trending structures would be expected to be a zone of high secondary permeability.

The drilling program at the Delong Drive site consisted of a shallow and a deep test hole (Table 2-1) at three locations (Exhibit 2-5). Location D1 (test holes TH-D1a and b) is situated on the south end of the site in the down-gradient direction from the proposed landfill cells based on the local groundwater flow.

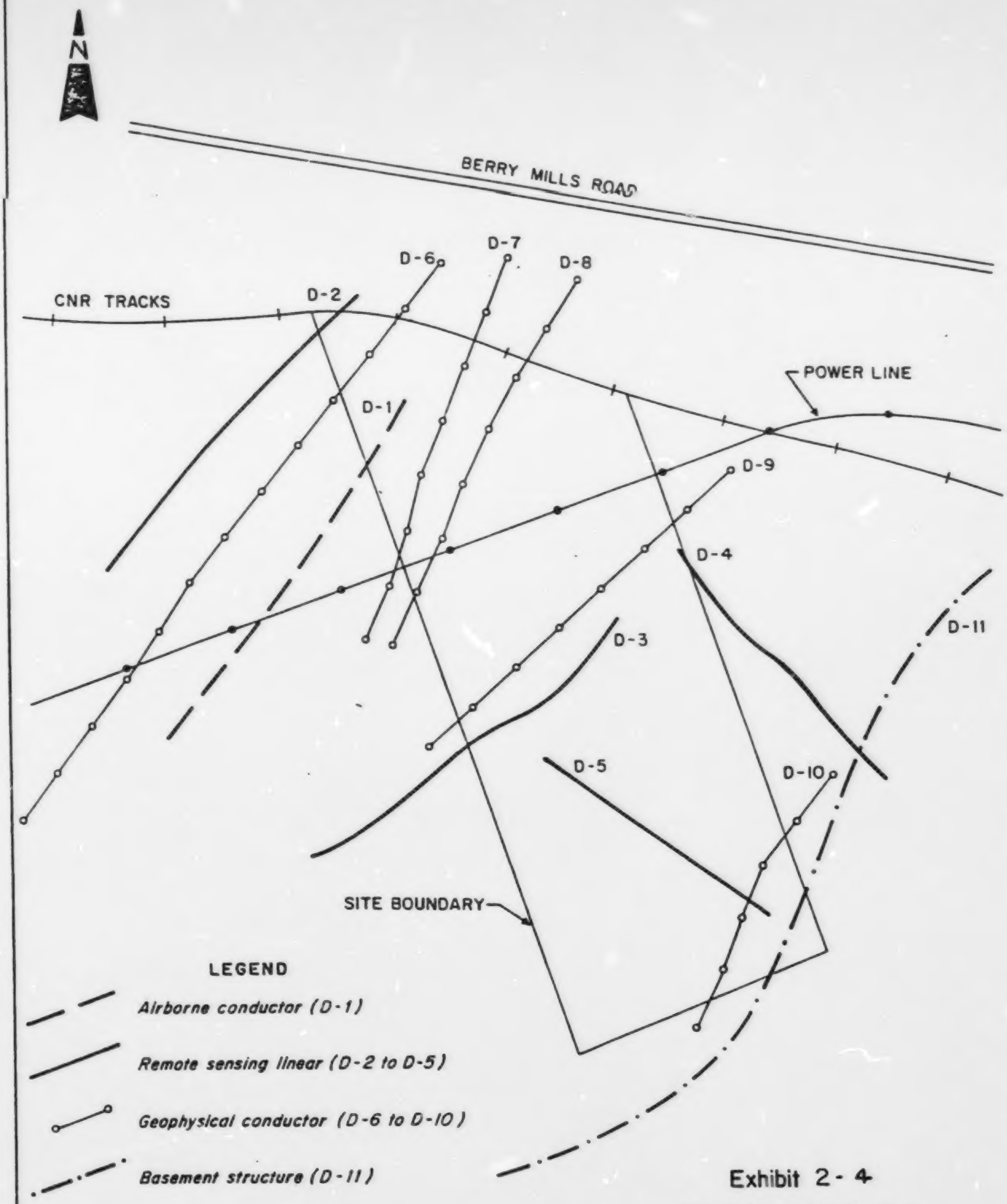

N
BERRY MILLS ROAD
D-7
D-6
D-8
CNR TRACKS
D-2
D-1
POWER LINE
D-9
D-4
D-3
D-11
D-5
D-10
SITE BOUNDARY
LEGEND
Airborne conductor (D-1)
Remote sensing linear (D-2 to D-5)
Geophysical conductor (D-6 to D-10)
Basement structure (D-11)

Exhibit 2- 4

DELONG DRIVE SITE

LOCATION OF LINEARS

SCALE 1 : 20,000

0 500m

Prepared by : MGI MARITIME GROUNDWATER INC.

Location D2 (test holes TH-D2a and b) is situated near the interpreted ground position of the intersection of the remote sensing linears D-3 and D-5 and geophysical conductor D-9. Location D3 (test holes TH-D3a and b) is situated near the junction of the northeasterly trending structures D-3 and D-9 with the northwesterly trending structure D-4.

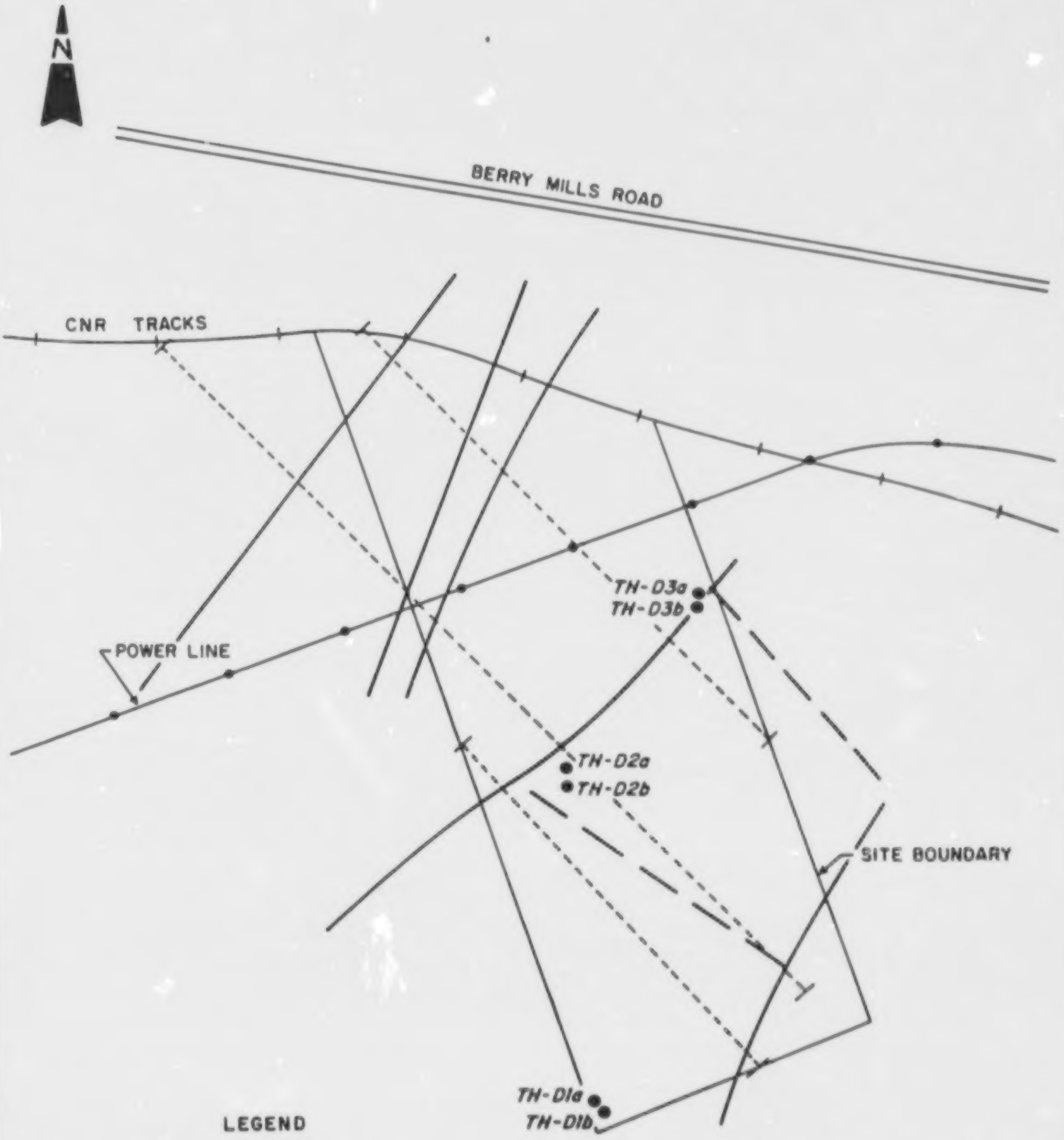
TABLE 2-1

Delong Drive Site: Test Hole Depths

Test Hole Number	Elevation of Hole (masl)	Depth of Casing (metres)	Depth of Test Hole (metres)
TH-D1a	42.58	6.1	7.6
TH-D1b	42.84	10.9	22.8
TH-D2a	48.37	6.4	7.6
TH-D2b	48.40	11.0	22.8
TH-D3a	56.44	10.4	22.8
TH-D3b	56.24	26.5	45.7

masl = Metres above sea level
Note: All measurements taken from top of casing

Bedrock at the Delong Drive site is characterized by flat-lying sedimentary rocks consisting of red to brown claystone, siltstone, and sandstone of the Salisbury Formation. Primary permeability of the Salisbury Formation is low, with an average yield of less than 0.75 litres per second reported in previous studies. A water well drilled in 1962 at the CN Hump Yard to the south of the site intersected 340 metres of sedimentary rock. Another hole drilled along Jonathan Creek, located to the north of the site, intersected 122 metres of siltstone and sandstone. Drilling conducted during the site selection phase of this study penetrated bedrock beneath the till layer, to a depth ranging from 1.5 to 5 metres. The predominant rock type was brown mudstone (claystone), with minor interlayers of siltstone and sandstone. The grain size of the lithological units was determined in the present hydrogeological study to have a general increase with depth, with a noticeable increase in the number of sandstone units and a decrease in claystone units after approximately 20 metres depth.


N
BERRY MILLS ROAD
CNR TRACKS
POWER LINE
TH-D3a
TH-D3b
TH-D2a
TH-D2b
SITE BOUNDARY
TH-D1a
TH-D1b

LEGEND

● TH-D1a *Testhole location (a- shallow, b-deep)*

Primary structure

Secondary structure

Geophysical survey line

Prepared by : MGI MARITIME GROUNDWATER INC.

Exhibit 2 - 5

DELONG DRIVE SITE

TESTHOLE LOCATIONS

SCALE 1 : 20,000

0 500 m

A thin layer of topsoil ranging in thickness from 30 to 96 cm was found to overlie the till layer throughout the site. The underlying till has been classified as a morainal loamy lodgement till.

Grain size analyses of the till indicated a composition of sand (35 to 39%), fines (45 to 47%) and gravel (16 to 18%). Previous laboratory testing conducted during the site selection phase (ACI 1991) has calculated a till hydraulic conductivity of 0.14 to 0.44 metres per year. Colour ranges from brown to reddish brown. Based on drill data obtained during the site selection and environmental impact assessment phases, till thickness ranged from 1.3 to 8.9 metres. The greatest thickness occurred on the northern portion of the site and at the southeastern end. The top of the bedrock underlying the till appears to have a consistent slope in a southeasterly direction.

Groundwater was encountered in all six of the test holes drilled at this site (Table 2-2). Static water levels ranged from 39.95 metres to 54.93 metres above sea level. The water level measurements show a downward groundwater gradient at this site (i.e. water levels in the shallow holes are at a higher elevation than in the deep holes).

TABLE 2-2

Delong Drive Site: Groundwater Elevations

Test Hole Number	Surface Elevation (masl)	Water Depth (metres)	Groundwater Elevation (masl)
TH-D1a	42.58	0.95	41.63
TH-D1b	42.84	2.89	39.95
TH-D2a	48.37	1.08	47.29
TH-D2b	48.40	1.45	46.95
TH-D3a	56.44	1.51	54.93
TH-D3b	56.24	9.33	46.91

masl = Metres above sea level
Note: All measurements taken from top of casing

Contoured representations of the water levels for the Delong Drive site are presented as Exhibits 2-6 and 2-7. The contours were derived using water levels obtained from piezometers located on the Delong Drive site as well as those located on the nearby Berry Mills Road site. Information presented on Exhibit 2-6 was derived from water levels in the shallow piezometers (7.6 metres depth), while Exhibit 2-7 is a representation of the water levels in the deep wells (22.8 metres depth). Both diagrams exhibit a southwesterly groundwater flow direction. An average groundwater gradient of 0.9% was calculated for the shallow wells, while a gradient of 1.0% was estimated based on data collected from the deep wells.

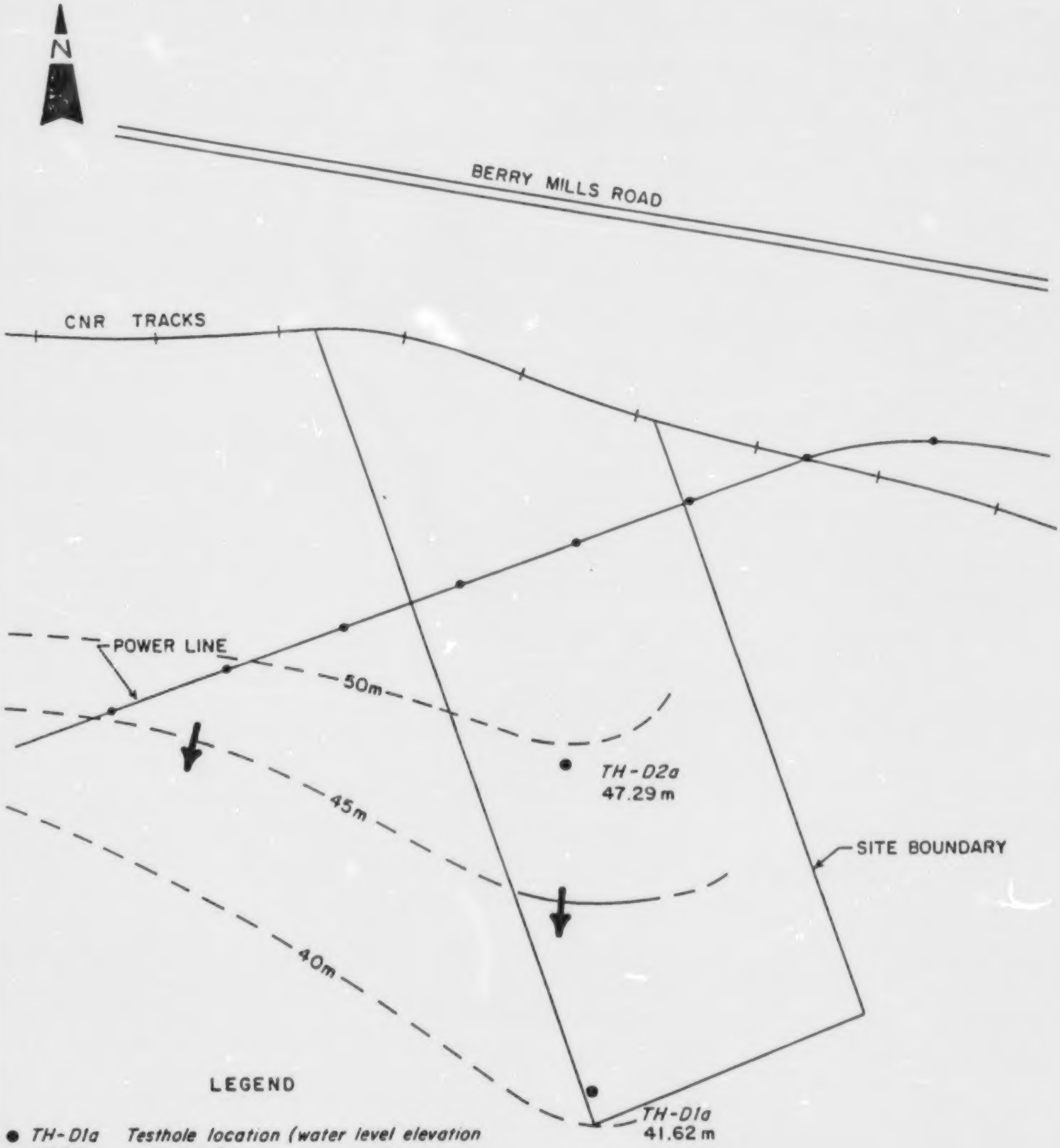
Following the measurement of static water levels, a permeability test was conducted on each test hole. Hydraulic conductivities were calculated from this data, and a range of 0.3 to 29.5 metres per year was indicated for the test holes (Table 2-3).

TABLE 2-3

Delong Drive Site: Hydraulic Conductivity Values

Test Hole Number	Test Hole Depth (metres)	Hydraulic Conductivity Values (metres per year)
TH-D1a	7.6	1.5
TH-D1b	22.8	29.5
TH-D2a	7.6	0.3
TH-D2b	22.8	2.2
TH-D3a	22.8	0.3
TH-D3b	45.7	1.5

Based on the obtained information on the groundwater gradients and hydraulic conductivities, and using an assumed porosity value of 15%, an estimate of the groundwater velocity can be made. It was found that for the shallow depths a range of 0.02 to 0.09 meters/year was obtained. The deeper strata indicated an average groundwater velocity range of 0.02 to 0.15 meters/year, although one anamalous test indicated a velocity of 1.97 meters/year. This higher velocity is probably a reflection of an increased fracture permeability close to the well bore tested.


N
BERRY MILLS ROAD
CNR TRACKS
POWER LINE
50m
45m
40m
TH-D2a
47.29 m
SITE BOUNDARY
TH-D1a
41.62 m

LEGEND

● TH-D1a 47.29m Testhole location (water level elevation in metres)

45m Equipotential line (approximate, inferred)

➚ Groundwater flow direction

Exhibit 2-G

DELONG DRIVE SITE
GROUNDWATER FLOW
TESTHOLE DEPTH : 7.6m
May, 1991
SCALE 1 : 20,000
0 500m

Prepared by : MGI MARITIME GROUNDWATER INC.

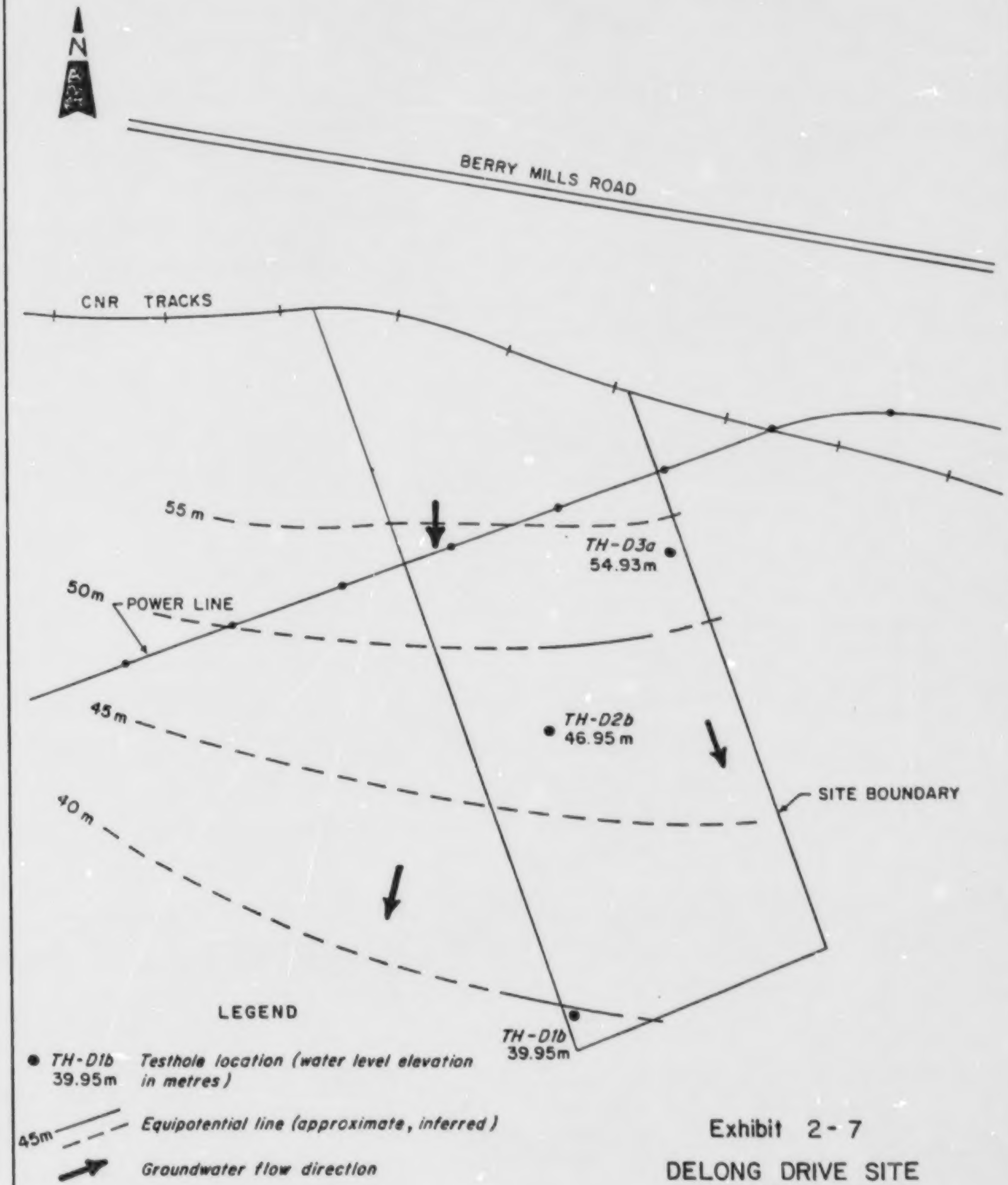

N
BERRY MILLS ROAD
CNR TRACKS
55 m
50m
POWER LINE
45 m
40 m
TH-D3a
54.93m
TH-D2b
46.95 m
SITE BOUNDARY
TH-D1b
39.95m
LEGEND
TH-D1b
39.95m
Testhole location (water level elevation in metres)
45m
Equipotential line (approximate, inferred)
Groundwater flow direction

Exhibit 2-7

DELONG DRIVE SITE
GROUNDWATER FLOW
TESTHOLE DEPTH : 22.8m
May, 1991

SCALE 1 : 20,000
0 500m

Prepared by : MGI MARITIME GROUNDWATER INC.

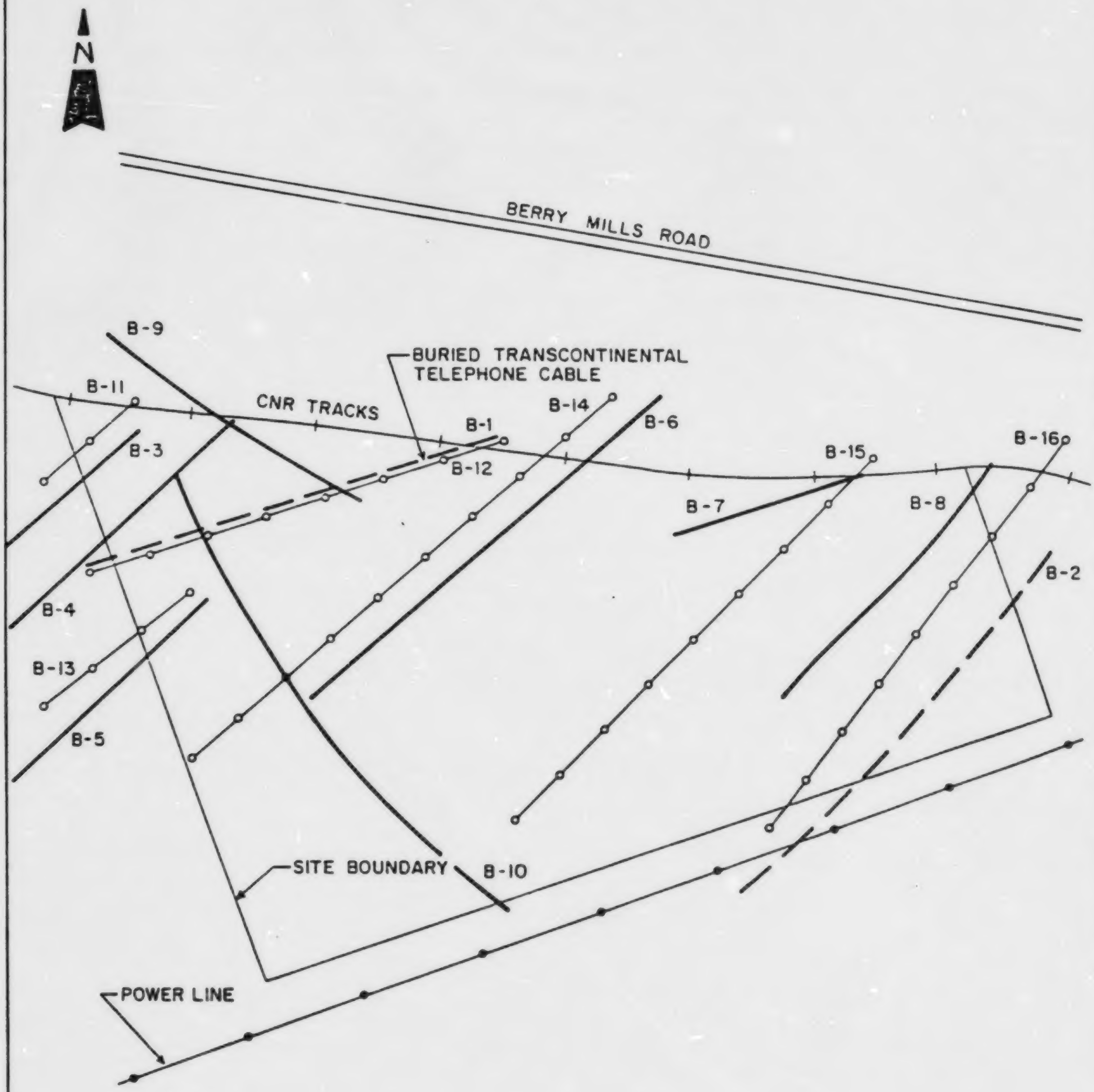
In summary, a hydrogeological assessment of the Delong Drive site identified several geological structures. Test drilling was conducted to evaluate selected structures. Groundwater flow was determined to be primarily in a southwesterly direction with a southeasterly influence on the eastern side of the site. Hydraulic conductivities range from 0.3 to 29.5 metres per year. The geological structures represent zones which may have relatively greater rates of groundwater migration. These structures (and possible subsidiary features) warrant consideration in the overall design of the landfill.

Berry Mills Road Site

The Berry Mills Road site is characterized by flat to gently rolling topography with elevations ranging from 45 to 70 metres above sea level. Drainage is to the south-southeast, towards the Petitcodiac River and its tributaries, at an average gradient of less than 2.0%.

Several features which represented potential zones of high secondary permeability were identified at the site (Exhibit 2-8). Airborne geophysical surveys from previous studies located two strong conductors, anomalies B-1 and B-2, within the site boundaries (Exhibit 2-8). Airborne conductor B-1 located in the northwestern corner of the site represented the buried transcontinental telephone cable which traverses the property. A second airborne conductor B-2, located in the southeastern corner of the property, was interpreted to represent a structure of regional significance. Satellite imagery outlined five northeasterly trending remote sensing linears (anomalies B-3 to B-8) and two northwesterly trending linears (anomalies B-9 and B-10). A ground geophysical survey resulted in the identification of six moderate strength to strong geophysical conductors (anomalies B-11 to B-16).

Geophysical conductor B-11 correlated with a remote sensing linear (B-3), as did geophysical conductors B-13 (with remote sensing linear B-5) and B-14 (with remote sensing linear B-6). Field investigations showed geophysical conductor B-14 coincided with a northeasterly trending depression (a lowland along which numerous swamps occur) which may be the surface trace of this lineament. Geophysical conductor B-12 was the strongest anomaly identified, but coincided with an airborne conductor B-1 and the position of a buried telephone cable. Geophysical conductor B-15, of moderate strength, had no coinciding remote sensing linear or airborne conductor.


N
BERRY MILLS ROAD
B-9
B-11
BURIED TRANSCONTINENTAL TELEPHONE CABLE
CNR TRACKS
B-14
B-6
B-1
B-3
B-12
B-15
B-16
B-7
B-8
B-2
B-4
B-13
B-5
SITE BOUNDARY
B-10
POWER LINE

LEGEND

- - - *Airborne conductor (B-1 to B-2)*

— *Remote sensing linear (B-3 to B-10)*

o—o *Geophysical conductor (B-11 to B-16)*

Prepared by: MGI MARITIME GROUNDWATER INC.

Exhibit 2-8

BERRY MILLS ROAD SITE

LOCATION OF LINEARS

SCALE 1:20,000

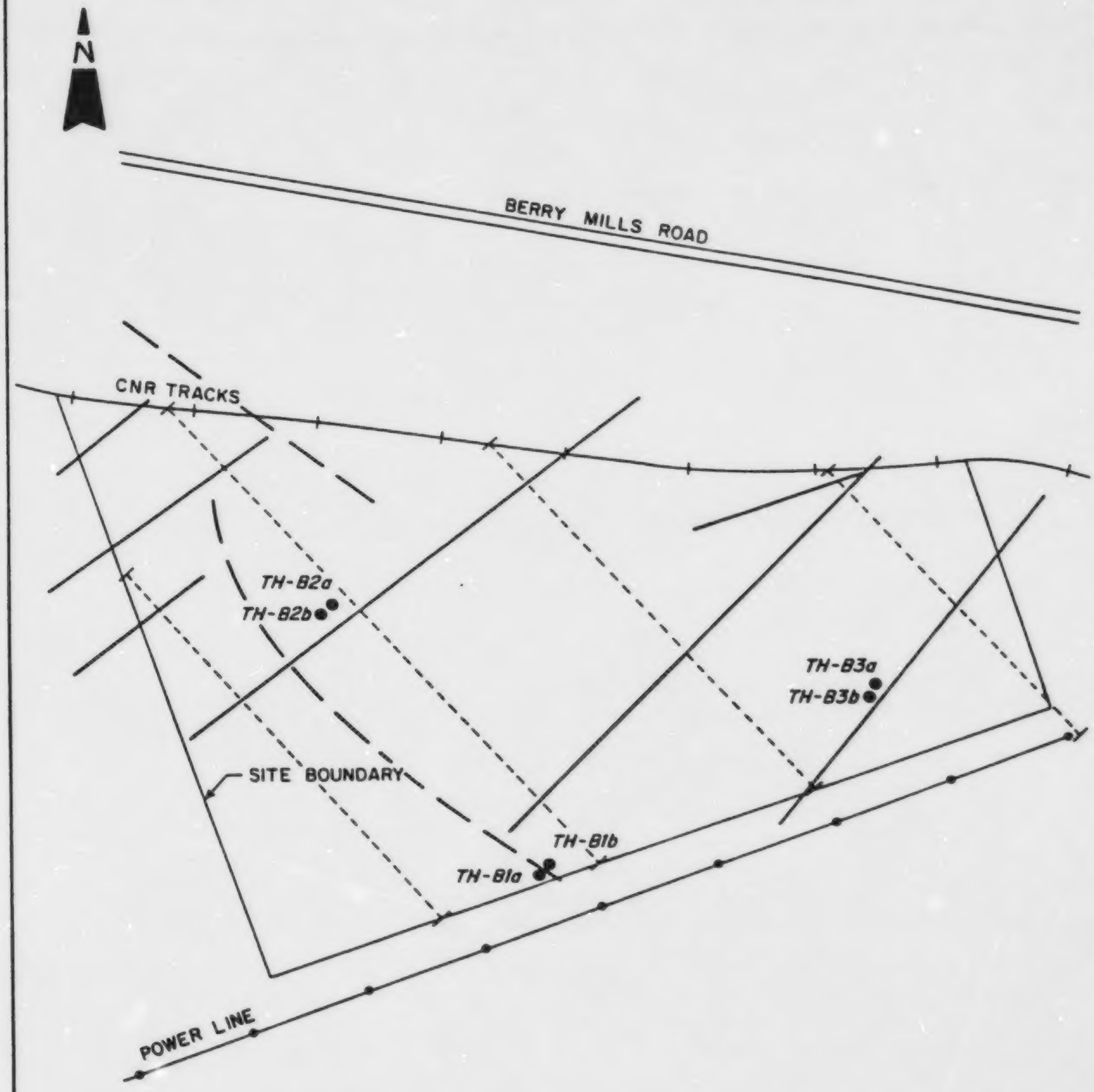
0 500m

Geophysical conductor B-16 was associated with a remote sensing linear (B-8) as well as an airborne conductor (B-2). This northeasterly trending lineament (B-16) was interpreted to represent a regional geological structure of significance. The northwesterly trending lineaments B-9 and B-10 were interpreted to represent possible secondary structures related to the regional northeasterly trend of geological structures in the Moncton area.

The drilling program at the Berry Mills Road site consisted of shallow and deep test holes (Table 2-4) at three locations (Exhibit 2-9). Location B1 (test holes TH-B1a and b) was situated on the southern boundary of the site in the down-gradient direction from the proposed landfill cells based on the local groundwater flow.

The wells were intended to test the feature associated with remote sensing linear B-10 and is a potential down-gradient monitoring site from the proposed landfill. Location B2 (test holes TH-B2a and b) was intended to test geophysical conductor B-14 and the remote sensing linear B-6. The wells also are a potential long term monitoring site situated up-gradient from the first cell location in the proposed landfill, relative to the local groundwater flow. Location B3 (test holes TH-B3a and b) was situated on a strong geophysical conductor B-16, with associated airborne conductor B-2 and remote sensing linear B-8.

Bedrock at the Berry Mills Road site is characterized by nearly flat-lying sedimentary rocks, consisting of red to brown siltstone, claystone (mudstone), and sandstone of the Salisbury Formation. Primary permeability of the Salisbury Formation is low, with an average yield of less than 0.75 litres per second reported in previous studies. A water well drilled in 1962 at the CN Hump Yard to the southeast of the site, penetrated 340 metres of red to brown sedimentary rocks. A drill hole located on Jonathan Creek northeast of the site intersected 122 metres of predominately red to brown siltstones and sandstones. Another well drilled to the west of the Berry Mills site intersected 120 metres of sedimentary rock. Drilling conducted for the site selection phase of this study penetrated bedrock beneath the till layer to a depth ranging from 1.5 to 5 metres. The predominant rock type intersected was a brown to reddish brown mudstone (i.e. claystone) with minor interlayers of siltstone and sandstone. The test hole drilling conducted in this study indicated that the relative percentage of siltstone, claystone and sandstone remained consistent with depth.


N
BERRY MILLS ROAD
CNR TRACKS
TH-B2a
TH-B2b
TH-B3a
TH-B3b
SITE BOUNDARY
TH-B1b
TH-B1a
POWER LINE

LEGEND

● TH-B1a	*Testhole location (a - shallow, b - deep)*
———	*Primary structure*
— —	*Secondary structure*
⊢-----⊣	*Geophysical survey line*

Prepared by : MGI MARITIME GROUNDWATER INC.

Exhibit 2 - 9
BERRY MILLS ROAD SITE
TESTHOLE LOCATIONS

SCALE 1 : 20,000
0 500m

TABLE 2-4

Berry Mills Road Site: Test Hole Depths

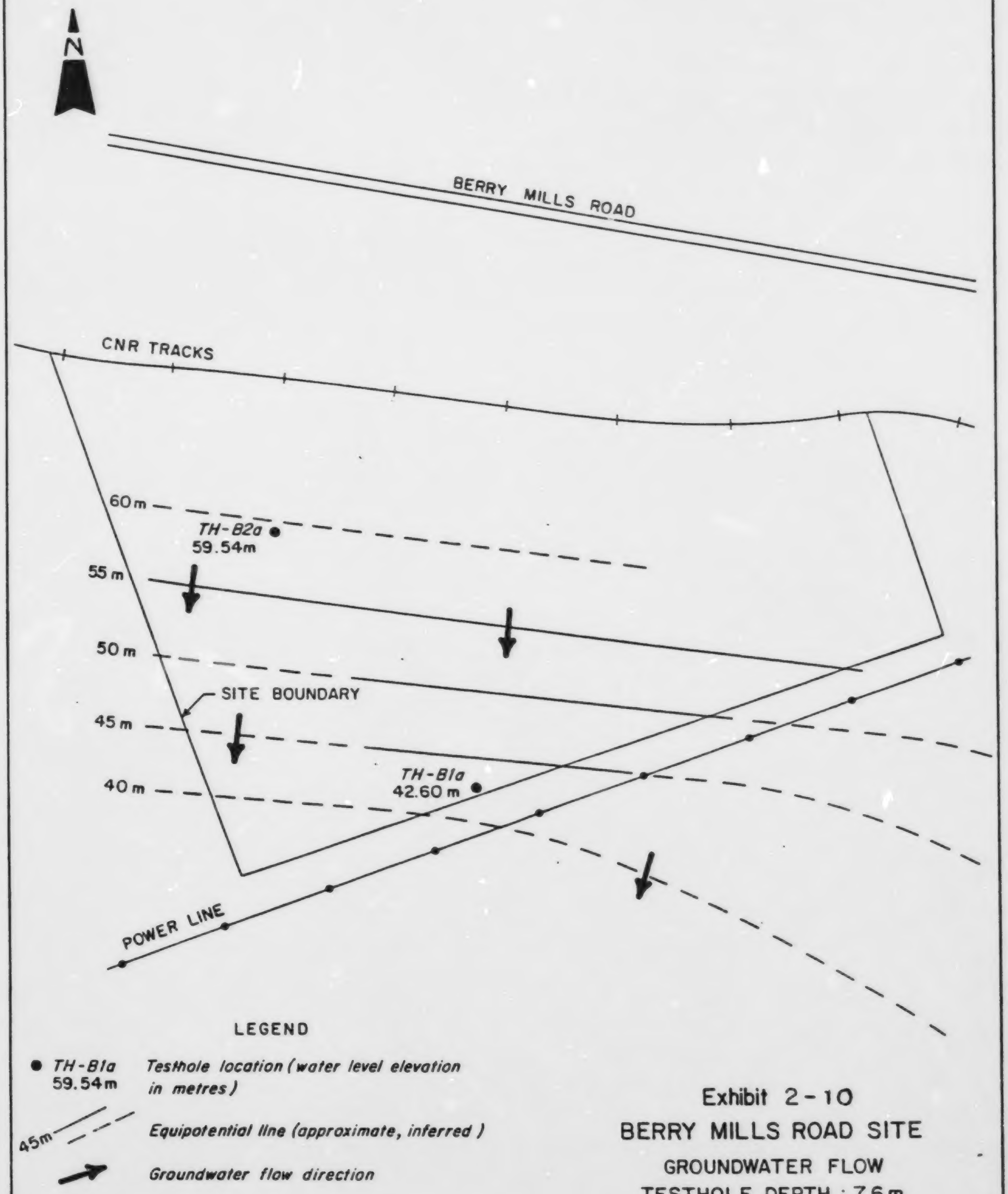
Test Hole Number	Elevation of Hole (masl)	Depth of Casing (metres)	Depth of Test Hole (metres)
TH-B1a	44.03	6.1	7.6
TH-B1b	43.71	11.0	22.8
TH-B2a	60.41	5.5	7.6
TH-B2b	60.40	11.3	22.8
TH-B3a	56.26	6.7	22.8
TH-B3b	56.31	26.5	45.7

masl = Metres above sea level
Note: All measurements taken from top of casing

A thin layer of topsoil ranging in thickness from 0.30 to 0.60 metres was found to overlie the till layer throughout the site. This soil consisted predominantly of a organic rich silt overlying a grey to brown silty sand layer with varying clay content. The main component of the overburden covering the Berry Mills Road site was classified as a morainal, loamy, lodgement till with silt (42 to 56%), sand (38 to 44%), and gravel (3 to 14%). Colour ranges from dark brown to reddish brown. Based on drill data collected during the site selection and environmental impact phases, till thickness ranged from three to eight metres. The bedrock surface underlying the till has a fairly consistent surface expression with a low slope to the south-southwest.

Groundwater was encountered in all six of the test holes drilled at this site (Table 2-5). Static water levels ranged from 42.58 metres to 55.44 metres above sea level. Water level measurements show a downward gradient (i.e. water levels in the shallow holes are at a higher elevation than in the deep holes).

Contoured representations of the water levels for the Berry Mills Road site are presented as Exhibits 2-10 and 2-11. The contours were derived using data collected from piezometers located at the Berry Mills Road site in conjunction with those located at the nearby Delong Drive site. Information presented on Exhibit 2-10 was derived from water levels in the shallow piezometer (7.6 metres depth), while Exhibit 2-11 is a representation of the water levels in the deep wells (22.8 metres depth). Both diagrams exhibit a southerly groundwater flow direction. An average groundwater gradient of 2.0% was calculated for the shallow wells, while a gradient of 1.5% was estimated for the deeper flow system.


N
BERRY MILLS ROAD
CNR TRACKS
60 m
TH-B2a
59.54m
55 m
50 m
SITE BOUNDARY
45 m
TH-B1a
42.60 m
40 m
POWER LINE
LEGEND
TH-B1a 59.54m
Testhole location (water level elevation in metres)
45m
Equipotential line (approximate, inferred)
Groundwater flow direction

Prepared by: MGI MARITIME GROUNDWATER INC.

Exhibit 2-10
BERRY MILLS ROAD SITE
GROUNDWATER FLOW
TESTHOLE DEPTH : 7.6 m
May, 1991
SCALE 1 : 20,000
0 500m

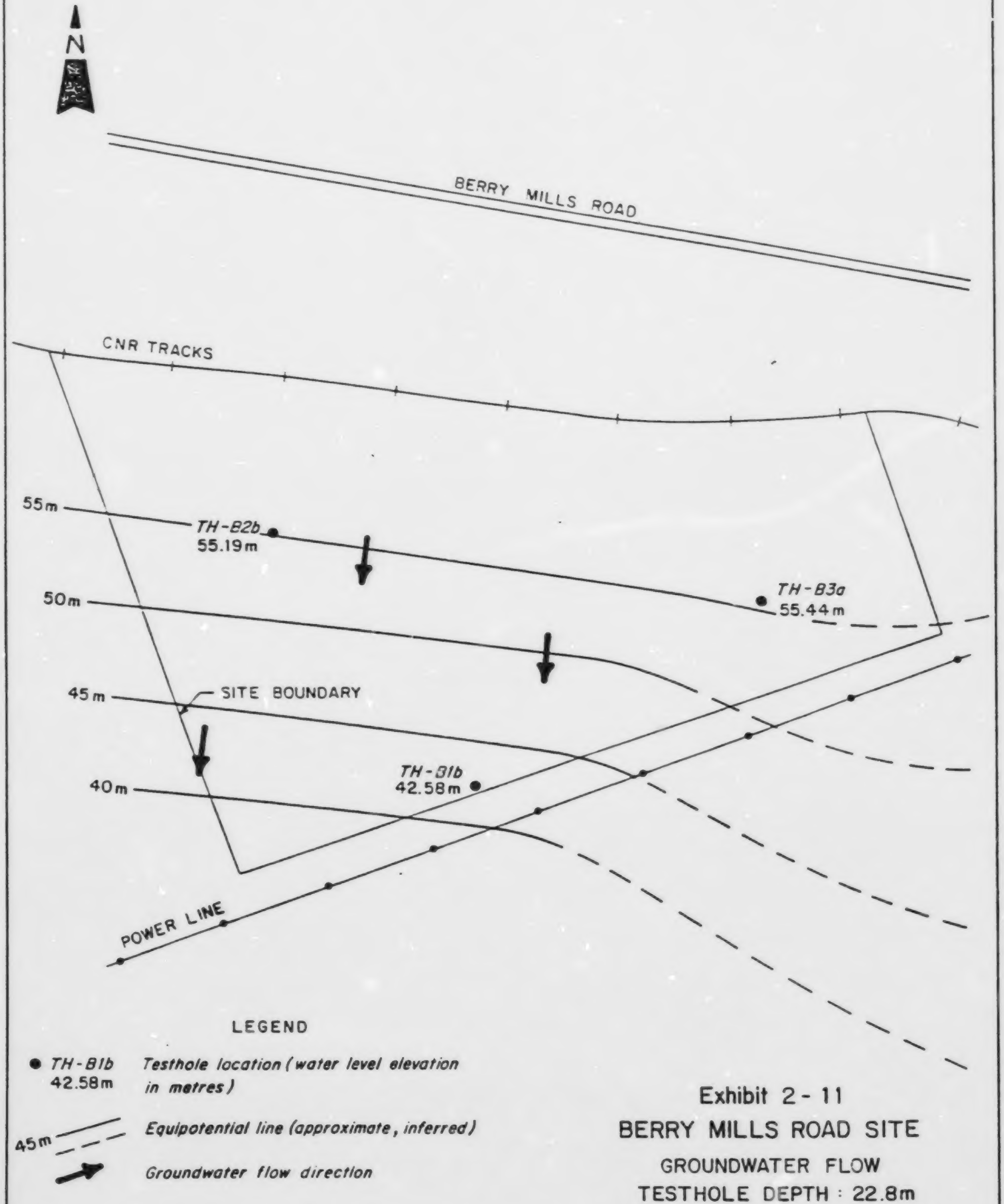

N
BERRY MILLS ROAD
CNR TRACKS
55m
TH-B2b
55.19m
TH-B3a
55.44m
50m
45m
SITE BOUNDARY
40m
TH-B1b
42.58m
POWER LINE
LEGEND
● TH-B1b 42.58m Testhole location (water level elevation in metres)
45m Equipotential line (approximate, inferred)
Groundwater flow direction

Exhibit 2 - 11

BERRY MILLS ROAD SITE

GROUNDWATER FLOW

TESTHOLE DEPTH : 22.8m

May, 1991

SCALE 1 : 20,000

0 500m

Prepared by : MGI MARITIME GROUNDWATER INC.

TABLE 2-5

Berry Mills Road Site: Groundwater Elevations

Test Hole Number	Surface Elevation (masl)	Water Depth (metres)	Groundwater Elevation (masl)
TH-B1a	44.03	1.43	42.60
TH-B1b	43.71	1.13	42.58
TH-B2a	60.41	0.87	59.54
TH-B2b	60.40	5.21	55.19
TH-B3a	56.26	0.82	55.44
TH-B3b	56.31	9.98	46.33

masl = Metres above sea level
NOTE: All measurements taken from top of casing

Following the measurement of static water levels, a permeability test was conducted on each test hole. Hydraulic conductivities were calculated from this data and a range of 1.0 to 63.3 metres per year was indicated (Table 2-6).

Using the obtained data on groundwater gradients and hydraulic conductivities, and assuming a 15% porosity value, an estimate of the groundwater velocity can be made. A velocity range of 0.96 to 2.60 meters/year was calculated for the shallow depths. The deeper depths indicated a range of 0.10 to 6.33 meters/year.

In summary, a hydrogeological assessment of the Berry Mills Road site identified several geological structures. Test drilling was conducted to evaluate selected structures. Groundwater flow was determined to be in a southerly direction. Hydraulic conductivities for the site range from 1.0 to 63.3 metres per year.

The geological structures represent zones which may have relatively greater rates of groundwater migration. These structures (and possible subsidiary features) warrant consideration in the overall design of the landfill.

TABLE 2-6

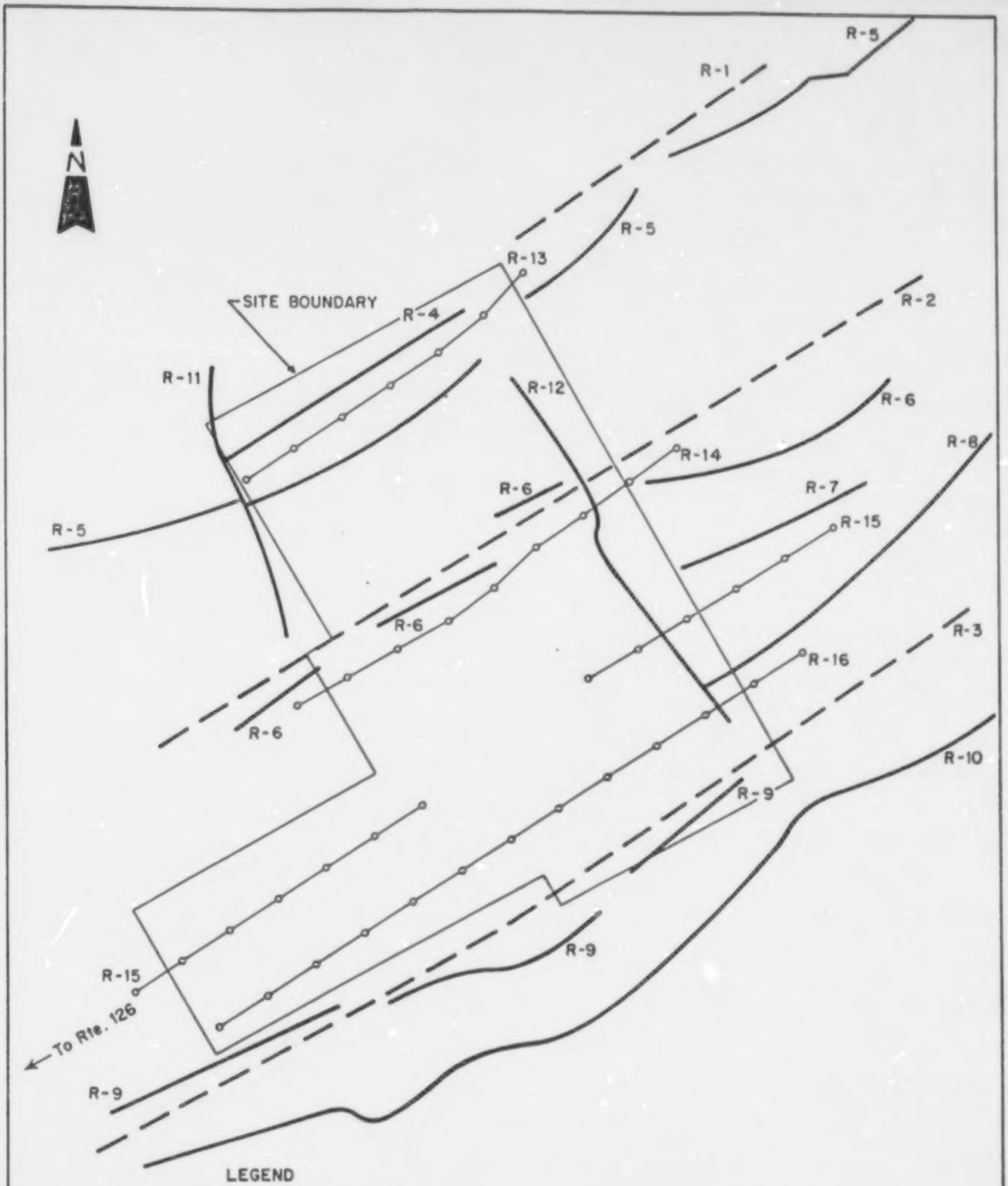
Berry Mills Road Site: Hydraulic Conductivity Values

Test Hole Number	Test Hole Depth (metres)	Hydraulic Conductivity Values (metres per year)
TH-B1a	7.6	19.6
TH-B1b	22.8	15.3
TH-B2a	7.6	7.2
TH-B2b	22.8	40.3
TH-B3a	22.8	1.0
TH-B3b	45.7	63.3

Route 126 Site

The proposed Route 126 site is situated on the northern flank of the Kingston Uplift. Elevations range from 100 to 130 metres above sea level. Drainage is to the northeast, towards the Cocagne River and its tributaries, which drains into the Northumberland Strait. An average surface gradient for this site was estimated at 1.9%.

Numerous features which represented potential zones of high secondary permeability were identified at the site (Exhibit 2-12). Airborne geophysical surveys from previous studies highlighted three airborne conductors (anomalies R-1 to R-3). Satellite imagery delineated seven northeasterly trending linears (anomalies R-4 to R-10) and two north-northwesterly trending linears (anomalies R-11 and R-12). A ground geophysical survey outlined four northeasterly trending geophysical conductors (anomalies R-13 to R-16). Geophysical conductor R-13, located in the extreme northern section of the site, coincided with an airborne conductor (R-1) and a remote sensing linear (R-4). Geophysical conductor R-14 has associated with it a strong regional scale airborne conductor (R-2) and a remote sensing linear (R-6). Geophysical conductor R-15 was a discontinuous structure which traversed the southern section of the proposed site and was associated with a remote sensing linear (R-7). Field investigations showed a discontinuous but pronounced, northeasterly trending, ground depression (gully) which may be the topographical expression of the geophysical conductor (R-15) and the remote sensing linear (R-7). Geophysical conductor R-16, located on the southern boundary of the proposed site, coincided with remote sensing linear R-8. Field investigations showed the presence of a slight northeasterly trending depression which may be the topographical expression of these anomalies (R-8 and R-16).


N
R-5
R-1
R-5
R-13
SITE BOUNDARY
R-4
R-2
R-11
R-12
R-6
R-14
R-8
R-6
R-7
R-5
R-15
R-6
R-3
R-16
R-6
R-10
R-9
R-15
To Rte. 126
R-9
R-9

LEGEND

- – – *Airborne conductor (R-1 to R-3)*
- — *Remote sensing linear (R-4 to R-12)*
- o—o *Geophysical conductor (R-13 to R-16)*

Prepared by: MGI MARITIME GROUNDWATER INC.

Exhibit 2-12

ROUTE 126 SITE

LOCATION OF LINEARS

SCALE 1:20,000

0 500m

The geophysical conductors (R-13, R-14, R-15, and R-16) were interpreted to represent subsidiary (i.e. parallel) structures associated with the Kingston Uplift. The area is geographically located approximately 300 to 400 metres south of the southern boundary of the proposed site. Remote sensing linears R-5, R-9 and R-11 had no associated ground geophysical conductors. Remote sensing linear R-9 coincided with an airborne conductor (anomaly R-3) and was interpreted to represent the northern contact of the Devonian geological unit present on Exhibit 2-2. The southern boundary of this same geological unit (Devonian) was interpreted to be represented by remote sensing linear R-10. Northwesterly trending lineaments (anomalies R-11 and R-12) were interpreted to represent possible secondary structures related to the regional northeasterly trend of geological structures in the Moncton area.

The drilling program at the Route 126 site consisted of shallow and deep test holes (Table 2-7) at three locations (Exhibit 2-13). Location R1 (test holes TH-R1a and b) was situated near the southern boundary of the site in the up-gradient direction from the proposed landfill cells based on the local groundwater flow. The wells were intended to investigate the features associated with geophysical conductor R-16. Location R2 (test holes TH-R2a and b) was intended to test geophysical conductor R-15, (and to be associated remote sensing linear R-7). Location R3 (test holes TH-R1a and b) was designed to test geophysical conductor R-14, (and associated remote sensing linear R-6, and airborne conductor R-2).

The Route 126 site is underlain by sedimentary rocks of Carboniferous age. Lithologies encountered at the site consist of red to green siltstone, sandstone and claystone with minor conglomerate. Hydrogeological data is not well documented in the vicinity of this proposed site. Primary permeabilities are expected to be low with inferred yields of less than 0.75 litres per second. Drilling conducted during the site selection phase of this project indicated the dominant rock type to be brown mudstone or claystone, with brown to grey-green sandstone, siltstone and minor grey conglomerate. Bedrock was penetrated during site selection drilling to a depth of 1.5 to 5.0 metres beneath the till layer. The test hole drilling conducted in this study indicated that the grain size of the lithological units exhibited a general decrease with depth, with a noticeable increase in the number of siltstone and claystone units and a decrease in sandstone units.

A topsoil layer ranging in thickness from 10 to 100 cm was observed to overlie the till. The soil consisted of predominantly organic rich silt overlying a grey or brown silty sand with varying clay content.

TABLE 2-7

Route 126 Site: Test Hole Depths

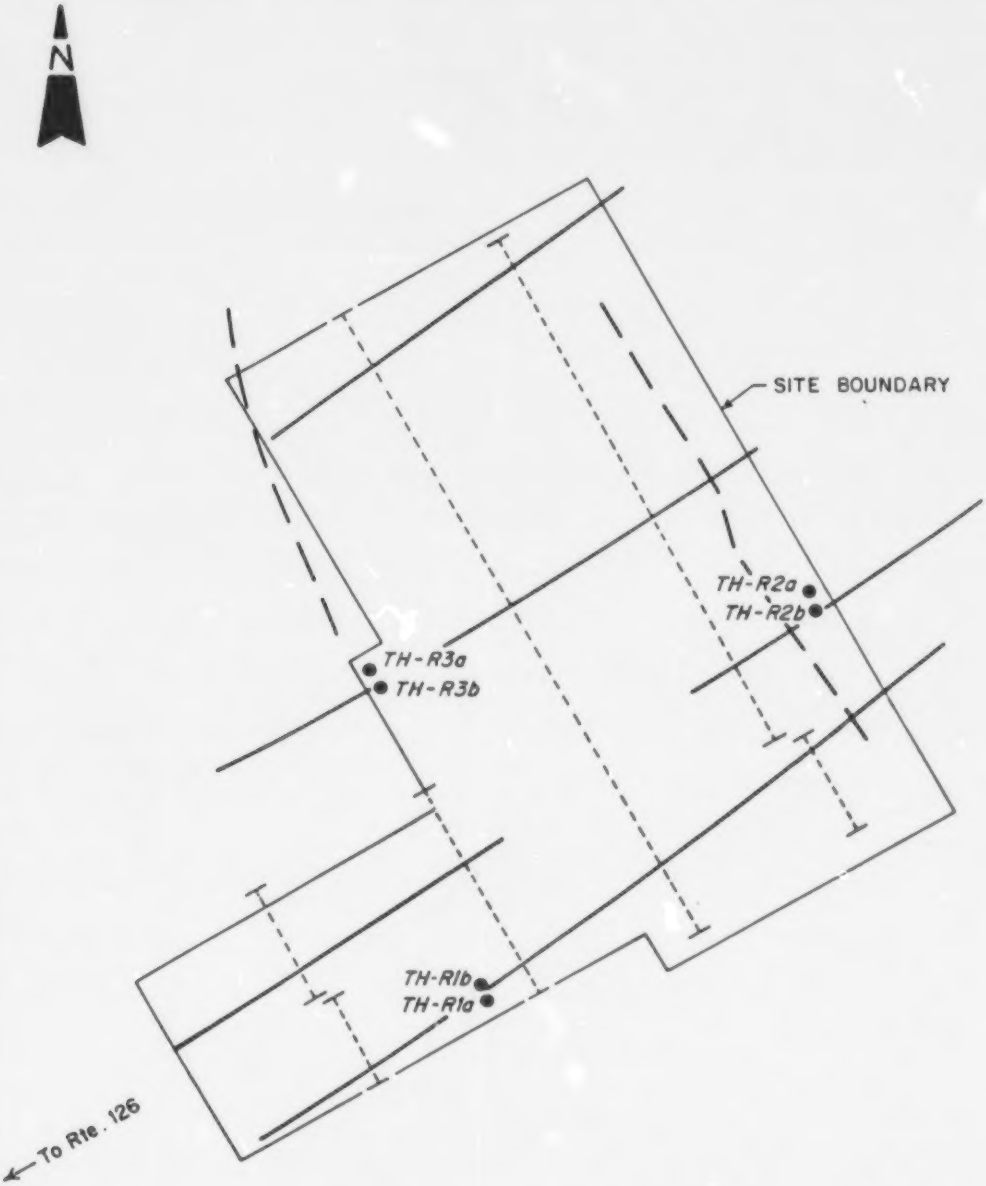
Test Hole Number	Elevation of Test Hole	Depth of Casing (metres)	Depth of Test Hole (metres)
TH-R1a	129.09	6.4	7.6
TH-R1b	128.58	10.7	22.8
TH-R2a	120.80	4.0	7.6
TH-R2b	121.32	12.2	22.8
TH-R3a	112.77	6.7	22.8
TH-R3b	112.42	26.8	45.7

masl = Metres above sea level
Note: All measurements taken from top of casing

The till layer overlying the bedrock was classified as a morainal veneer till. The till was found to consist of clay and silt (49 to 54%), sand (38 to 46%), and gravel (5 to 8%). Previous permeability testing conducted during the site selection phase (ACI 1991) has estimated a till hydraulic conductivity of 0.04 to 1.07 metres per year. The colour of the till ranges from a dark brown to a reddish brown dependent on the characteristic of the underlying bedrock. Till thickness ranged from zero to 5.5 metres.

Groundwater was encountered in all six of the test holes drilled at this site (Table 2-8). Static water levels ranged from 110.08 metres to 123.41 metres above sea level. The water level measurements show a downward groundwater gradient at all three test sites.

A contoured representation of the water levels for the Route 126 site is presented as Exhibit 2-14. The contours were derived using information from piezometers 22.8 metres in depth. Only two piezometers had a depth of 7.6 metres, which prevented the construction of a shallow aquifer flow diagram. A groundwater gradient of 1.0% was calculated from the data presented in Exhibit 2-14.


N
SITE BOUNDARY
TH-R2a
TH-R2b
TH-R3a
TH-R3b
TH-R1b
TH-R1a
To Rte. 126

LEGEND

● TH-R1a Testhole location (a - shallow, b - deep)

—— Primary structure

— — Secondary structure

⊢- - - -⊣ Geophysical survey line

Prepared by: MGI MARITIME GROUNDWATER INC.

Exhibit 2-13
ROUTE 126 SITE
TESTHOLE LOCATIONS

SCALE 1:20,000
0 500m

TABLE 2-8

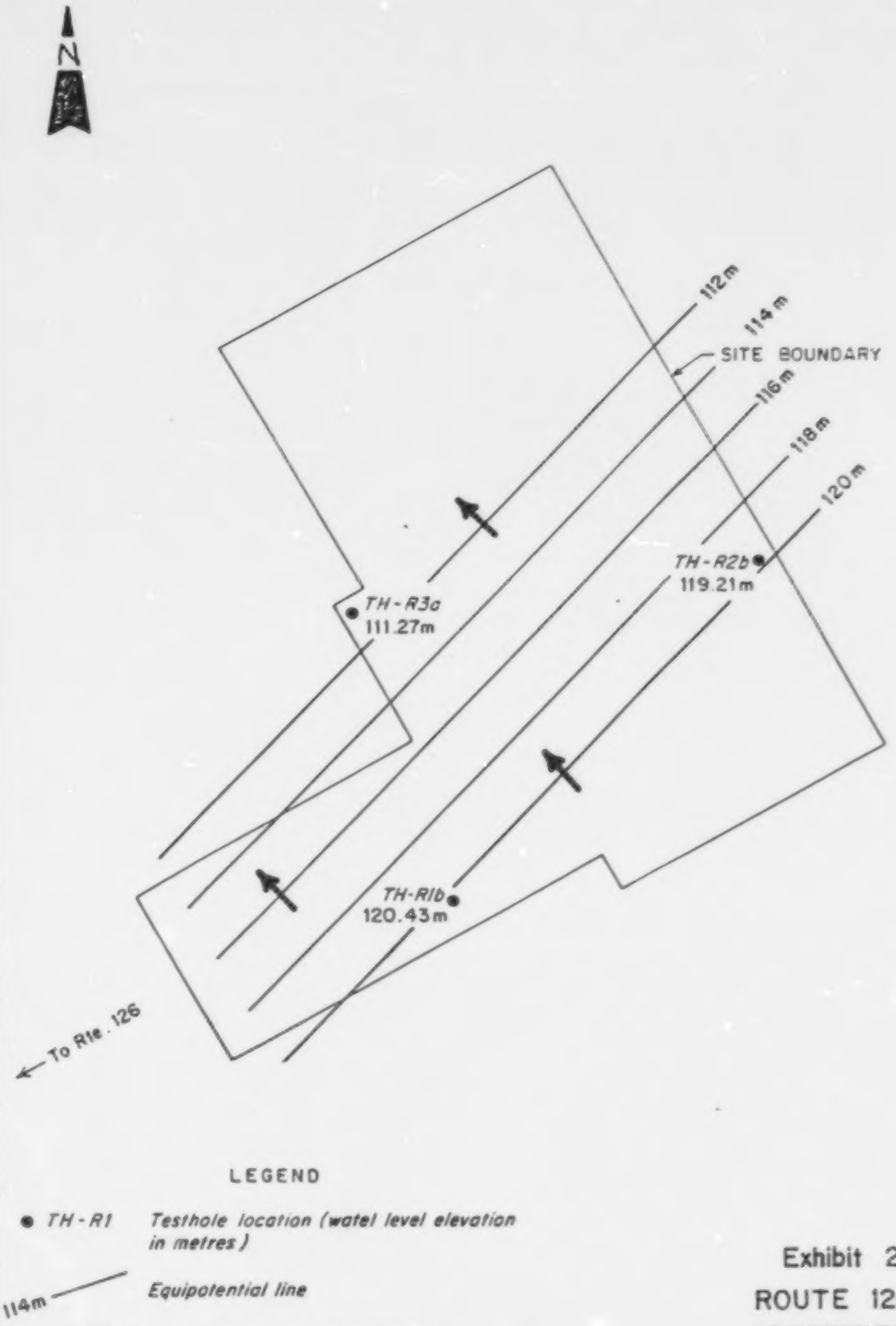
Route 126 Site: Groundwater Elevations

Test Hole Number	Surface Elevation (masl)	Water Depth (metres)	Groundwater Elevation (masl)
TH-R1a	129.09	5.68	123.41
TH-R1b	128.58	8.15	120.43
TH-R2a	120.80	1.09	119.71
TH-R2b	121.32	2.11	119.21
TH-R3a	112.77	1.50	111.27
TH-R3b	112.42	2.34	110.08

masl = Metres above sea level
Note: All measurements taken from top of casing

Following the measurement of static water levels, a permeability test was conducted on each test hole. Hydraulic conductivities were calculated from this data, and a range of 2.8 to 810.8 metres per year was indicated for the test holes (Table 2-9). The range in values can be explained by differences in secondary permeability. The shallow bedrock aquifer (less than 7.6 metres depth) has displayed larger hydraulic permeability values than the deep holes. Analysis of the hydraulic conductivity values indicate that the major fracture zones are located in the shallow bedrock, although more permeable zones were also detected in the deep wells at sites 2 and 3. The amount of fracturing inferred in the bedrock aquifer is consistent with the geographical positioning of the site, approximately 400 to 500 metres north of the geologically complex Kingston Uplift. The Kingston Uplift has been identified as a structurally complex feature.

Using the data obtained on the groundwater gradient and hydraulic conductivities, and assuming a porosity of 15%, an estimate of the groundwater velocity can be made for the deeper depths tested. The velocity range for the shallow depths could not be estimated due to the lack of hydraulic gradient data. A groundwater velocity range of 0.19 to 14.76 meters/year was calculated for the deeper strata. The wide range of velocity values reflects the inconsistent presence of fracture related permeability at the Route 126 site.


N
112m
114m
116m
118m
120m
SITE BOUNDARY
TH-R3a
111.27m
TH-R2b
119.21m
TH-R1b
120.43m
To Rte. 126

LEGEND

● *TH-R1* *Testhole location (watel level elevation in metres)*

114m ——— *Equipotential line*

➚ *Groundwater flow direction*

Prepared by: MGI MARITIME GROUNDWATER INC.

Exhibit 2-14

ROUTE 126 SITE

GROUNDWATER FLOW
TESTHOLE DEPTH : 22.8m
May, 1991
SCALE 1 : 20,000
0 500m

TABLE 2-9

Route 126 Site: Hydraulic Conductivity Values

Test Hole Number	Test Hole Depth (metres)	Hydraulic Conductivity Values (metres per year)
TH-R1a	7.6	396.7
TH-R1b	22.8	2.8
TH-R2a	7.6	810.8
TH-R2b	22.8	221.4
TH-R3a	22.8	139.1
TH-R3b	45.7	73.6

In summary, a hydrogeological assessment of the Route 126 site identified several geological structures. Test drilling was conducted to evaluate selected structures. Groundwater flow was determined to be in a northwesterly direction. Hydraulic conductivities for the site range from 2.8 to 810.8 metres per year. The geological structures represent zones which may have relatively greater rates of groundwater migration. These structures (and possible subsidiary features) warrant consideration in the overall design of the landfill.

2.3 Overburden and Bedrock Characteristics

2.3.1 SUBSURFACE INVESTIGATION

Delong Drive Site

A total of twenty-six test pits were put down over the Delong Drive Site in the preliminary investigations. The locations of the test pits are indicated on Drawing 1-1 (Appendix G). The test pits were extended to refusal in the bedrock or to the extent of reach of the excavator. The details of the soil and bedrock strata, encountered in each test pit, were recorded and representative samples of the soils were obtained for detailed examination. Groundwater conditions in each test pit was also noted.

The test pits indicated the overburden at the site generally ranged from 1.9 meters to greater than 4.6 meters thick. This consisted of 300 mm to 600 mm of topsoil overlying the reddish brown glacial till. The bedrock underlying the till is sedimentary rock, usually a fine grained mudstone. The groundwater table was not encountered in the test pits although groundwater was found seeping along the interface between the till and the bedrock or between the topsoil and the till in 7 of the 26 test pits.

Following a review of the data from the test pits, an additional detailed subsurface investigation was performed at the site to extend the investigation to a greater depth and to obtain additional data.

The detailed subsurface investigation at the Delong Drive Site consisted of boreholes put down at the eleven locations indicated in Drawing 1-1. The locations of the boreholes were selected, given the existing access to the site, to provide coverage of the site supplementing the test pits and to allow investigation of features of interest. The boreholes were advanced through the overburden into the bedrock to depths ranging from 6.4 meters in Borehole 107 to 13.9 meters in Borehole 109. The overburden was sampled in each borehole at 1.5 meter intervals using a 50 mm O.D. split spoon sampler in Standard Penetration Tests (SPT), which also provided an indication of the relative density of the soil. The bedrock was sampled by continuous coring with NQ size diamond coring equipment.

Following completion of each borehole, a standpipe piezometer was placed in the borehole. The piezometer consisted of 50 mm I.D. pvc pipe with a 1.5 meter screened section at the tip. A bentonite sand was placed at the bedrock to allow monitoring of groundwater levels in the bedrock. A second piezometer was installed at each location and sealed in the till above the bedrock surface to allow groundwater monitoring in the overburden. These piezometers were monitored periodically through November and December of 1990, to determine groundwater levels.

The elevations and locations at each test hole were tied into the N.B.G.I.C. grid.

Soil and bedrock samples from the boreholes were transferred to ACI's Moncton laboratory for further examination and testing of representative samples. Testing on overburden samples consisted of tests for grain size distribution, moisture content, Atterberg limits and determination of the coefficient of hydraulic conductivity.

The boreholes confirmed the subsurface conditions found in the test pits. A thin surficial veneer of topsoil, 300 mm to 600 mm thick, was found overlying the glacial till at the site. This generally consisted of an organic silt overlying a grey or brown silty sand with a varying clay content.

The glacial till at the site is a lodgement till which occurs in a belt on the north side of the Petitcodiac River and extends from Salisbury to Haut Aboujagane. The thickness of the till stratum encountered in the test holes ranged from 1.3 meters in Test Pit 7 to 8.7 meters in Borehole 101 and was generally greater than 2 meters thick. The soil samples obtained in the investigation for this study indicated the till is a dark brown to reddish brown clayey silty sand with some gravel. Grain size analyses of representative samples showed 16 to 18 percent gravel, 35 to 39 percent sand, and 45 to 47 percent fines. Tests for Atterberg limits showed a liquid limit between 18 and 20 percent and a plastic limit of 14 percent, which indicates the fines are a silty clay. The Unified Soil Classification for this till is SC-SM. The hydraulic conductivity of the till determnined in laboratory testing was 1.4×10^{-8} to 4.5×10^{-9} meters per second.

The bedrock at the site is sedimentary rock, predominantly a soft brown mudstone with interbeded sandstone and siltstone. These rocks are of Pennsylvanian age and form part of the Salisbury Formation. The top 1 to 2 meters of the mudstone is often highly weathered to a residual soil. The bedrock is horizontally bedded. Fractures are generally closely spaced; however, the fractures are tight.

No groundwater table was identified at the site in this investigation; however, groundwater was often encountered flowing along the surface of the glacial till or along the bedrock surface. Monitoring of piezometers installed in boreholes indicated groundwater was perched locally in the till, in Boreholes 101, 105, and 106 at elevations ranging from 47.6 to 51.9 meters. Groundwater was perched in the bedrock in Borehole 109 at elevation 35.3 meters. Groundwater movement below the surface of the till will be mainly through zones of increased intergranular or secondary fracture permeability in the till or bedrock.

Berry Mills Road Site

The detailed subsurface investigation at the Berry Mills Road Site consisted of boreholes put down at six locations to augment the existing data from a previous investigation at the site performed by ACI in 1986 for the City of Moncton.

The 1986 investigation consisted of 12 boreholes put down at the locations indicated in Drawing 1-2 (see Appendix G). The boreholes were extended to a depth ranging from 4.6 m in Borehole 6 to 10.8 meters in Borehole 2. Sampling was performed with a 50 mm O.D. split spoon sampler in SPT. The sampling intervals were every 1.5 meters in the top 3 to 5 meters extending to every 3 meters below this depth. The test holes were advanced by augering into the soft, sedimentary bedrock.

The 1990 detailed investigation consisted of boreholes at 6 additional locations as indicated in Exhibit 1-2. These boreholes were extended to depths ranging from 10.7 meters in Borehole 201 to 14 meters in Borehole 204. Sampling in the overburden in each hole consisted of SPT with a 50 mm O.D. split spoon sampler at 1.5 meter intervals. The bedrock was sampled by continuous coring with NQ size diamond coring equipment. Following completion of each borehole, a standpipe piezometer consisting of 50 mm I.D. pvc pipe with a 1.5 m screened section at the tip was placed in the hole. A bentonite seal was then placed at the bedrock surface to permit monitoring of the groundwater in the bedrock to that depth. A second borehole was drilled at each location to install a second piezometer in the till above the bedrock surface. This second piezometer permitted monitoring of groundwater levels in the overburden. The piezometers were monitored through November and December of 1990 to determine groundwater levels.

In both investigations, the elevation and location at each borehole were tied into the N.B.G.I.C. grid.

After both investigations, the samples were transferred to the ACI laboratory in Moncton for further examination. Representative samples of the overburden were tested for grain size distribution, moisture content and Atterberg limits.

The boreholes from the 1990 investigation generally confirmed the findings of the 1986 investigation. A thin surficial veneer of topsoil 300 mm to 600 mm thick was found overlying the glacial till at the Berry Mills Site. This generally consisted of an organic silt overlying a grey or brown silty sand with a varying clay content.

The glacial till at the site is a lodgement till which occurs in a belt on the north side of the Petitcodiac River, and extends from Salisbury to Haut Aboujagane. In the west half of the site, the till layer was generally between 5 and 7 meters thick, while in the east half, the thickness ranged from 2.4 to 4.4 meters. The till is a dark brown to reddish brown, sandy silty clay to clayey silty sand, with some gravel. Grain size analyses of six representative samples shows 3 to 14 percent gravel, 38 to 44 percent sand and 42 to 56 percent fines. Tests for Atterberg limits showed a liquid limit between 19 and 21 percent and a plastic limit of 14 to 15 percent, which indicates the fines are a silty clay. The Unified Soil Classification for this till is CL-ML to SC-SM. The hydraulic conductivity of the till should be similar to that determined in laboratory testing for the Delong Drive Site, in the order of 10^{-8} to 10^{-9} meters per second.

No hydraulic conductivity testing was done. Due to grain size and density similarity between till samples on the Delong Drive Site and this site, and the relative proximity of the sites, the hydraulic conductivity determined for the till at the Delong Drive Site was considered representative.

The bedrock at the site is sedimentary rock, predominantly a soft brown mudstone, with interbedded sandstone and siltstone. These rocks are of Pennsylvanian age and form part of the Salisbury

Formation. The top 1 to 3 meters of the mudstone is often highly weathered to a residual soil. The sandstone and siltstone layers are usually faintly to slightly weathered. The bedrock is horizontally bedded. Fractures are generally closely spaced; however, the fractures are tight.

No groundwater table was identified at the site in this investigation; however, groundwater was encountered perched locally in the till in Boreholes 2, 7 and 8 in the 1986 investigation. Monitoring in the piezometers installed in the present investigation indicated groundwater was perched locally in the bedrock in Boreholes 202 and 204. Borehole 201, which penetrated to the lowest elevation, 34.2 meters, showed no evidence of an artesian water table, reinforcing the theory that these were probably locally confined water pockets. In addition groundwater was encountered flowing across the surface of the glacial till.

Groundwater movement below the surface of the till will be mainly through zones of increased intergranulated or secondary fracture permeability in the till or bedrock.

Route 126 Site

A total of twelve test pits were put down at the Route 126 Site in the preliminary investigation. The locations of the test pits are indicated on Drawing 1-3 (see Appendix G). The test pits were confined to the southern end of the site due to the dense vegetation over the northern section. The test pits were extended to the depth of refusal in the bedrock or the extent of reach of the excavator. The test pits indicated the thickness of overburden at the site ranged from 1.8 m to 3.7 m. The overburden consisted of 600 mm to 1100 mm of topsoil overlying 1.2 m to 3.0 m of glacial till. The bedrock underlying the till was sedimentary rock, predominantly sandstone with some layers of mudstone or conglomerate. Groundwater was only encountered in 3 of the 12 test pits and this was at or below the bedrock surface.

At the Route 126 Site, the detailed investigation consisted of boreholes at five additional locations to those investigated with the test pits, as indicated in Exhibit 1-3. Location of test holes on the north portion of the site was limited by the lack of access due to the dense vegetation on this portion of the site. However, due to the relatively consistent geography of the area, it was felt the expense of cutting access to enable additional test holes was not required at this stage of the investigation.

The boreholes were extended through the overburden, into the bedrock, to depths ranging from 10.8 to 11 meters. The overburden was sampled at 1.5 meter intervals with the 50 mm O.D. split spoon sampler in Standard Penetration Tests (SPT). The bedrock was sampled continuously by coring with NQ size diamond coring equipment.

A standpipe piezometer was placed in each borehole at the completion of drilling. The piezometers consisted of 50 mm I.D. pvc with a 1.5 meter screened section at the tip. A bentonite seal was placed at the bedrock surface to allow monitoring of the groundwater levels in the bedrock. A second borehole was drilled at each location and another piezometer was sealed in the till above the bedrock surface to allow monitoring of the groundwater in the overburden. Falling and rising head permeability tests were conducted in this piezometer to determine the hydraulic conductivity of the till. The piezometers were monitored periodically through November and December of 1990.

The elevations and locations of the test holes were tied into the N.B.G.I.C. grid.

Following completion of the boreholes, the soil and bedrock samples were transferred to the ACI laboratory for further examination. Representative soil samples were tested for grain size distribution, moisture content and Atterberg limits.

A summary of the subsurface conditions of the site determined in the investigations is provided below. A surficial layer of topsoil, 100 mm to 1000 mm thick, was found overlying the glacial till or bedrock at the site. The topsoil consisted of organic silt overlying a grey or brown silty sand with varying clay content.

In all test holes at the site, except Borehole 404, a stratum of glacial till was found beneath the topsoil covering the bedrock. This is a morainal blanket of lodgement till. The thickness of the till layer in the test holes generally ranged from 1.4 to 3.3 meters. The till is a dark brown to reddish brown clayey silty sand to sandy silty clay, with some gravel. Grain size analyses of representative samples showed 5 to 8 percent gravel, 38 to 46 percent sand and 49 to 54 percent fines. The Unified Soil Classification for the till is CL to SC-SM. The hydraulic conductivity of till based on in situ field testing at the site, ranges from 10^{-8} to 10^{-9} meters per second. The relative density of the till was compact with N-values from Standard Penetration Tests ranging from 21 to 28.

The bedrock at the site is sedimentary rock of Pennsylvanian age, predominantly a red to yellowish brown, fine to medium grained sandstone occasionally grading to conglomerate, with interbedded mudstone and siltstone. The bedrock is often highly weathered at the bedrock surface, becoming slightly to moderately weathered with depth. The bedrock is horizontally bedded. Fractures are generally closely spaced; however, fractures are fairly tight. Clay was found on some fracture surfaces.

No groundwater table was identified at the site to the depths tested in this investigation. Groundwater was encountered in the bedrock in Boreholes 401, 402, 403, and 404. The piezometer level of the groundwater in these test holes was above the bedrock surface. The piezometric elevations ranged from 119.9 meters in Borehole 402 to 92.3 meters in Borehole 404. The bedrock type varied from mudstone to sandstone in these holes. These groundwater volumes appear to be locally confined with artesian pressures.

In addition groundwater was noted flowing along the bedrock surface in Test Pits 2 and 5. In Borehole 405, groundwater was encountered perched in the glacial till.

Groundwater movement below the surface of the till will be mainly through zones of increased intergranular or secondary fracture permeability in the till or bedrock.

2.3.2 SOIL EROSION

It can be assumed that all topsoil will be stripped in the areas developed for the waste management facility. Also, the in situ till will be the prime source of cover material. Therefore, for erosion and sediment control studies, the glacial till underlying the topsoil veneer is the soil of concern. In considering erosion, the universal soil loss equation is used to estimate the soil loss. The general form of the equation is as follows:

$$A = R \times K \times LS \times C \times P$$

where
A = soil loss (tons/acre-year)
R = rainfall erosion index (100 ft x tons/acre x in/hr)
K = soil erodibility factor (tons/acre per unit of R)
LS = slope length and steepness factor (dimensionless)
C = vegetative cover factor (dimensionless)
P = erosion control practice factor (dimensionless)

For erosion studies, the soil characteristics define the soil erodibility factor, which is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Texture is the principal factor affecting K, but structure, organic matter and permeability also contribute. The values of the soil erodibility factor generally range from 0.02 to 0.69.

A soil with an erodibility factor of 0.02 would have no silt size particles, and would be a cohesive clayey soil or a coarse grained sand and gravel with less than 15 percent of the sand sized particles smaller than 0.1 mm in diameter. These soils would resist erosion due to, respectively, the cohesive attraction of the clay and the physical size and weight of the particles. A soil with an erodibility factor of 0.65 would be 100 percent silt size particles, the particles being readily susceptible to erosion.

Delong Drive Site

The glacial till at the site is a dark brown to reddish clayey silty sand with gravel. Grain size analyses of representative samples grouped according to the MIT classification showed 15 to 16 percent clay sized particles, 27 to 28 percent silt, 7 to 8 percent very fine sand, 28 to 31 percent sand and 18 to 22 percent gravel. Tests for Atterberg limits showed a liquid limit of between 18 and 20 percent, and a plastic limit of 14 percent which indicated the soil fines are a silty clay. The Unified Soil Classification for this till is SC-SM.

Based on the analyses of the soil samples, the soil erodibility factor for the glacial till at the Delong Drive Site would range from 0.24 to 0.28.

Berry Mills Road Site

The glacial till at the site is of the same till body as at the adjoining Delong Drive Site. The grain size distribution of representative samples from the Berry Mills Road Site, grouped according to the MIT classification, showed 16 to 22 percent clay, 27 to 28 percent silt, 8 to 11 percent very fine sand, 29 to 35 percent sand and 7 to 14 percent gravel.

The fines content of these samples is higher than those from the Delong Drive Site and the Unified Soil Classification is CL-ML to SC-SM.

Based on the grain size distribution of the till samples, the soil erodibility factor would range from 0.26 to 0.27.

Route 126 Site

The glacial till at the Route 126 Site is a dark brown to reddish brown clayey silty sand to sandy silty clay, with some gravel. The grain size analyses of representative till samples from the site, grouped according to the MIT classification, showed 17 to 24 percent clay, 27 to 29 percent silt, 7 to 10 percent very fine sand, 30 to 37 percent sand and 7 to 12 percent gravel. The Unified Soil Classification for the till is CL to SC-SM.

The soil erodibility factor of the glacial till at the Route 126 Site, based on these representative samples, is 0.25 to 0.29.

2.3.3 EROSION CONTROL

In construction and operation of the proposed waste management facility, erosion and the resulting sedimentation will possibly occur at several locations. These consist of the initial construction of the site infrastructure, such as roads, the landfill cell and the borrow pit.

The existing vegetation must be maintained in areas not developed and vegetative growth will be promoted over areas once utilized. This vegetation should maintain the soil in these areas.

It is anticipated that the amount of sedimentation, due to erosion, will not be great due to the low soil erodibility factor of the glacial till. In addition, the slopes constructed in development of the landfill site will not be steep, lessening the erosion potential. Collection ditches will be used to collect any erosion products that do occur. These will incorporate silt traps and a sedimentation pond. In this way, any sediment in run-off from the site will be removed prior to allowing the water to discharge from the site.

2.4 Surface Watercourses

2.4.1 GENERAL CHARACTERISTICS

Water quality information for streams draining the three potential sites has been obtained from published data, discussions with various resource managers, and samples taken during four sampling runs as part of this study.

Water samples were collected at 18 locations on five watercourses adjacent to the three potential sites for the proposed integrated waste management facility. Five points on Michael's Creek were selected with respect to the Delong Drive Site (See Exhibit 2-15, Site A). Five points on Somers Creek and four points on Jonathan Creek were selected with respect to the Berry Mills Road Site (See Exhibit 2-15, Site B). Two points on the Cocagne River and two points on Shaw Brook were chosen given the position of the Route 126 Site (See Exhibit 2-16, Site C).

Table 2-10 provides a summary of guidelines and requirements for water quality. Parameters listed in this table were chosen with the intent to reflect water column characteristics of importance to aquatic organisms. The data summarized in Tables 2-11 and 2-12 provides background levels on these parameters for the various watercourses prior to the development of an integrated waste management facility at the potential sites.

The Delong Drive Site (Exhibit 2-15, Site A) is poorly drained because of the lack of defined drainage channels and the low permeabilities of the existing overburden. A portion of the central western section of the site is boggy. To the west of this site, three small ponds flow into Michael's Creek.

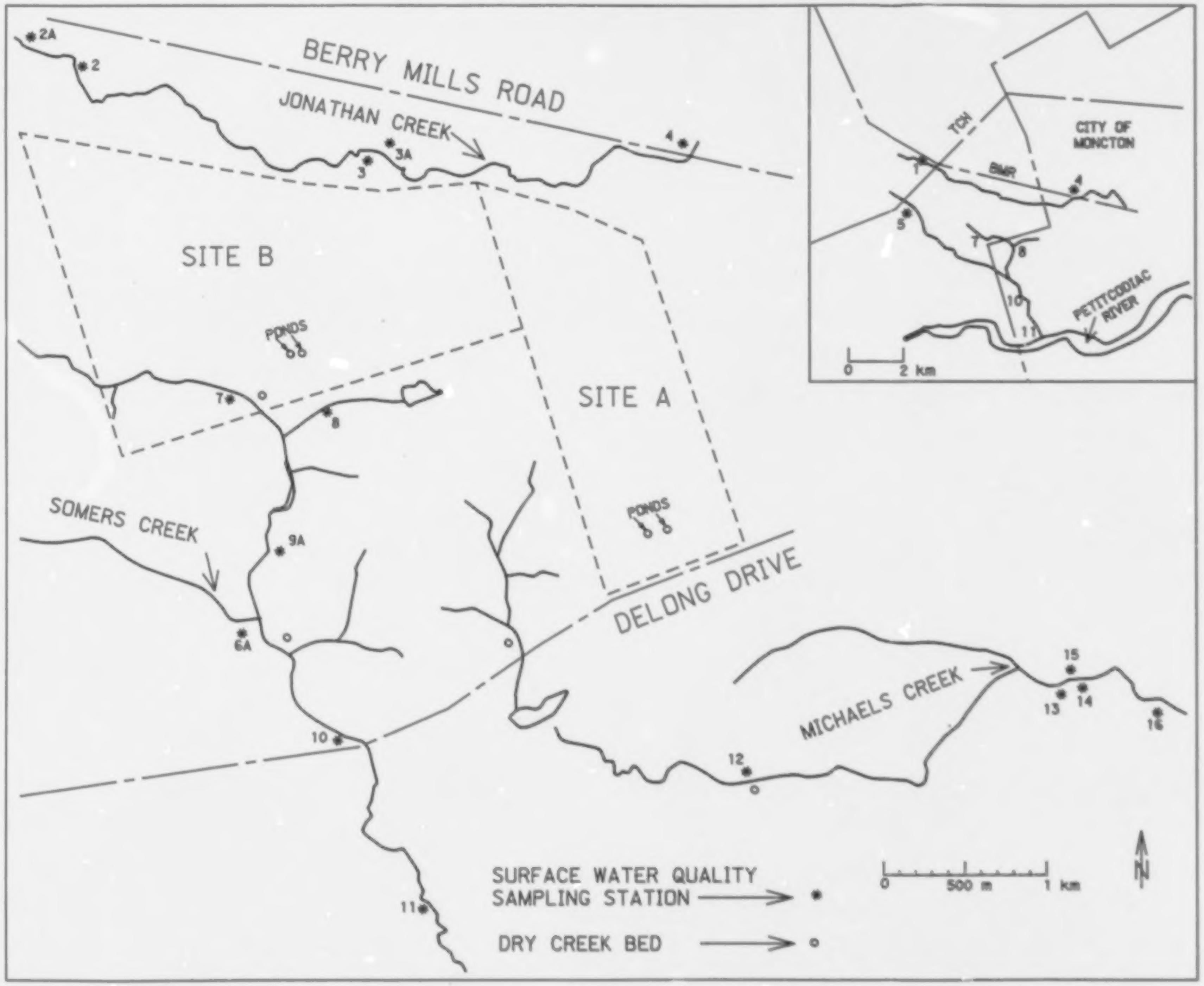

BERRY MILLS ROAD
JONATHAN CREEK
2A
2
3
3A
4
SITE B
PONDS
SITE A
PONDS
7
8
SOMERS CREEK
9A
6A
10
11
DELONG DRIVE
MICHAELS CREEK
12
13
14
15
16
SURFACE WATER QUALITY SAMPLING STATION
DRY CREEK BED
0
500 m
1 km
N
TCH
BMR
CITY OF MONCTON
1
4
5
7
8
10
11
PETITCODIAC RIVER
0
2 km

Exhibit 2-15: Potential waste management sites a) north of Delong Drive and B) south of Berry Mills Road showing the location of sedimentation and leachate collection ponds, and the locations of water quality and aquatic habitat evaluation (A) sampling stations (*1 - *16) on Jonathan Creek, Somers Creek, and Michael's Creek.

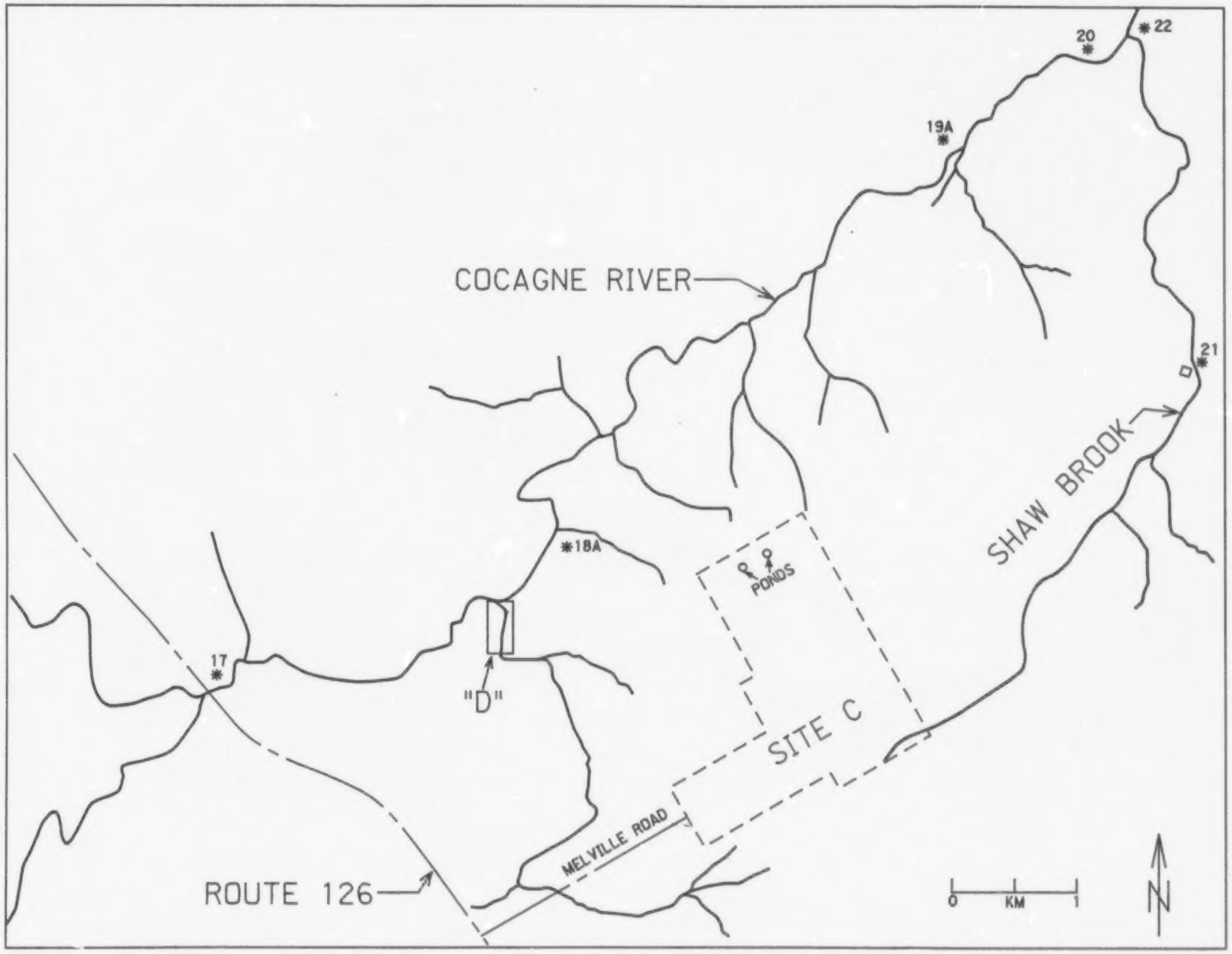

22
20
19A
COCAGNE RIVER
21
SHAW BROOK
18A
PONDS
17
"D"
SITE C
MELVILLE ROAD
ROUTE 126
0
KM
1
N

EXHIBIT 2-16: Potential waste management site east of Route 126 (Site C) showing the location of sedimentation and leachate collection ponds, and the locations of water and aquatic habitat evaluation (A) sampling stations (*17 - *22) on the Cocagne River and Shaw Brook. Tributaries of note are "D" and Shaw Brook where rectangles show locations where habitat evaluation was carried out earlier by other agencies.

TABLE 2-10

Water quality guidelines and requirements pertaining to effluent discharges and surface water quality guidelines for the protection of aquatic life in streams adjacent to the Westmorland/Albert Integrated Waste Management Facility

	PARAMETERS (#2-17 in ppm)	LANDFILL LEACHATE[1] (mg . L^{-1})	VALUES IN RECEIVING STREAM	
			CCREM[2] (1987) (mg . L^{-1})	Hutt, 1988 (mg . L^{-1})
1.	pH	6.0-9.5	6.5-9.0	6.5-9.0
2.	alkalinity	n.a.	n.a.	20 mg/l
3.	nitrate-nitrite	n.a	<10	<10
4.	total P	n.a	n.a.	<0.1
5.	total suspended solids	80	increase of 10	n.a.
6.	5-day BOD	40	n.a.	n.a.
7.	COD	100	n.a.	n.a.
8.	dissolved [O_2]	n.a.	Warm water: 5 - 6 mg/l Cold water: 6.5 - 9.5 mg/l	n.a. n.a.
9.	Aluminum (Al)	n.a.	pH<6.5; 0.005 pH>6.5; 0.1	<1.5
10.	Cadmium	n.a.	0.0002-0.0018	0.0002
11.	Chromium (Cr)	0.5	0.02	n.a.
12.	Copper (Cu)	0.5	0.002-0.004	0.0174
13.	Iron (Fe)	5	0.3	n.a.
14.	Mercury (Hg)	n.a.	0.0001	n.a.
15.	Nickel (Ni)	0.5	0.025 - 0.150	n.a.
16.	Lead (Pb)	n.a.	0.001-0.007	0.05
17.	Zinc (Zn)	0.5	0.03	0.03
18.	Faecal Coliforms[3]	n.a.	200 faecal coliforms/100 ml	n.a.
19.	Total Coliforms		n.a.	n.a.

[1] P.E. Haines, N.B.D.O.E. (per. comm.), 1991

[2] Canadian Council of Resource and Environment Ministers' Guidelines for Freshwater Aquatic Life

[3] Canadian Council of Resource and Environment Ministers' Guidelines for Recreational Water Quality and Aesthetics.

* n.a. = not available

TABLE 2-11

Surface Water Quality Results (median values)
Measured for streams adjacent to Proposed Waste Management Facility Sites
(A) Delong Drive Site (B) Berry Mills Raod Site (C) Route 126 Site

STATION *	TRIBUTARY	No. of Samples	pH	Alkalinity $mgCaCO_3/l$	$NO_3 + NO_2$ mg/l	Total P mg/l	D.O.C. mg/l	S.S. mg/l	T.D.S. mg/l	Al mg/l	Cd mg/l	Cu mg/l	Fe mg/l	Hg µg/l	Pb mg/l	Zn mg/l
	PETITCODIAC SYSTEM															
2	Jonathan Creek	4	7.15	42.1	0.12	0.03	14.3	1.5	195.0	0.3	<0.01	0.01	0.47	<0.2	<0.02	0.01
3	Jonathan Creek	4	7.23	41.5	0.11	0.02	13.4	0.5	190.0	0.15	<0.01	<0.01	0.34	<0.2	<0.02	0.01
4	Jonathan Creek	4	7.37	46.7	0.09	0.02	11.7	1.0	150.0	0.15	<0.01	0.01	0.39	<0.2	<0.02	<0.01
5	Somers Creek	4	7.00	17.7	<0.01	0.02	13.3	2.5	158.0	0.2	<0.01	0.03	0.40	<0.2	<0.02	<0.01
7	Somers Creek	4	5.65	4.0	<0.01	0.03	30.7	<1.0	76.0	0.5	<0.01	<0.01	0.64	<0.2	<0.02	<0.01
8	Somers Creek	2	5.77	5.6	0.01	0.15	22.5	8.3	35.0	1.3	<0.01	<0.01	1.12	<0.2	<0.02	0.01
10	Somers Creek	4	6.80	18.5	0.05	0.03	20.2	1.1	96.0	0.4	<0.01	0.01	0.30	<0.2	<0.02	0.01
11	Somers Creek	4	6.80	23.0	0.06	0.04	15.6	2.5	133.0	0.4	<0.01	0.01	0.35	<0.2	<0.02	0.01
12	Michael's Creek	4	6.35	15.6	0.03	0.03	22.9	1.4	91.5	0.2	<0.01	0.01	0.72	<0.2	<0.02	0.01
13	Michael's Creek	2	7.15	55.8	0.43	0.31	9.0	6.0	203.0	0.1	<0.01	0.02	1.40	<0.2	<0.02	0.03
14	Michael's Creek	4	7.28	58.7	0.44	0.21	11.8	7.5	264.0	0.4	<0.01	0.02	0.88	<0.2	<0.02	0.04
15	Michael's Creek	3	6.65	24.8	0.33	0.04	1.2	<1.0	111.0	0.1	<0.01	<0.01	0.06	<0.2	<0.02	0.01
16	Michael's Creek	3	7.15	47.1	0.10	0.09	9.1	6.5	365.0	0.1	<0.01	<0.01	0.84	<0.2	<0.02	0.02
	COCAGNE SYSTEM															
17	Cocagne River	4	5.50	3.3	0.03	0.06	31.6	4.5	54.0	0.3	<0.01	0.02	1.35	<0.2	<0.02	0.01
20	Cocagne River	4	6.20	5.6	0.02	0.05	26.2	3.5	46.0	0.4	<0.01	0.02	0.85	<0.2	<0.02	0.02
21	Shaw Brook	3	7.05	18.0	0.05	0.03	18.3	3.0	92.0	0.2	<0.01	<0.01	0.68	<0.2	<0.02	<0.01
22	Shaw Brook	3	7.25	24.1	0.02	0.03	12.0	2.0	79.0	0.3	<0.01	<0.01	0.60	<0.2	<0.02	<0.01

* All metals analysed in total form.

** Results for the only sample collected at Station #1 are given in Appendix F.

TABLE 2-12

Total and Faecal Coliform Bacteria Counts from select locations within the Petitcodiac Basin Area and the Cocagne River adjacent to proposed sites: (A) Delong Drive Site, (B) Berry Mills Road Site, and (C) Route 126 Site

SITE	WATER COURSE	SAMPLE STATION *	TOTAL COLIFORM (COUNT/100 ml)				FAECAL COLIFORM (COUNT/100 ml)			
			APRIL 1991	JUNE 1991	AUG. 1991	SEPT. 1991	APRIL 1991	JUNE 1991	AUG. 1991	SEPT. 1991
A & B	JONATHAN CREEK	2	n.a.	35	n.a.	83	n.a.	n.d.	156	83
	JONATHAN CREEK	3	130	n.a.	n.a.	n.a.	59	n.a.	n.a.	n.a.
	JONATHAN CREEK	4	128	60	n.a.	13	55	40	60	3
B	SOMERS CREEK	10	21	35	n.a.	n.a.	2	18	n.a.	n.a.
	SOMERS CREEK	11	24	n.a.	n.a.	36	n.d.	n.d.	135	36
A	MICHAEL'S CREEK	12	1	n.a.	n.a.	27	1	n.a.	19	3
	MICHAEL'S CREEK	14	46	TNTC	n.a.	n.a.	15	60	n.a.	n.a.
	MICHAEL'S CREEK	15	n.a.	n.d.	n.a.	n.d.	n.a.	n.d.	n.d.	n.d.
	MICHAEL'S CREEK	16	n.a.	TNTC	n.a.	94	n.a.	TNTC	TNTC	81
C	COCAGNE RIVER	17	9	200	n.a.	30	2	90	10	20
	COCAGNE RIVER	20	12	20	n.a.	n.a.	n.d.	14	30	n.a.
	SHAW BROOK	21	n.a.	TNTC	n.a.	60	n.a.	TNTC	60	60
	SHAW BROOK	22	n.a.	17	n.a.	8	n.a.	6	TNTC	n.d.

n.a. = not available
n.d. = not detected
TNTC = too numerous to count (>300 coliforms/100 ml)
Source: District Medical Health Office Laboratory;
Moncton, New Brunswick, April 1991

The Berry Mills Road Site (Exhibit 2-15, Site B) is also poorly drained due to the same reasons as the Delong Drive Site. Jonathan Creek flows past the northern perimeter of the site between the CNR tracks (i.e., the northern boundary line) and Berry Mills Road. Although this is a major drainage channel, most of the proposed site drains into shallow pannes or Somers Creek to the south and eventually the Petitcodiac River.

The Route 126 Site (Exhibit 2-16, Site C) is relatively flat and boggy in the clear cut portion of the area and at the northern perimeter of the site (i.e., north of the Garland Road). Drainage is generally to the north and northwest towards the Cocagne River with the exception of the southern section of the site which drains to the upper reaches of Shaw Brook.

2.4.2 WATER QUALITY

Water quality results for all four sampling runs, which are summarized in Table 2-11, are presented in Appendix E.

Flow measurements using the "float technique" of Vromans (1986) were only taken in the June sampling run. No flow rates were measured in August or September because water levels were below those needed for the use of Vromans' technique.

In general, pH levels were within the CCREM guidelines (see Table 2-10) of 6.5 - 9.0 for surface waters containing salmonoids. However, median pH levels were lower than these guidelines at stations #7 and #8 of Somers Creek and stations #17 and #20 of the Cocagne River. This may have been due to the acidic nature of the watershed in these areas and/or the presence of acid precipitation.

The nutrients represented by nitrate-nitrite, which are important to freshwater systems, remained at levels below the CCREM guidelines. Total P enrichment was only evident at Michael's Creek (stations #13 and #14), where values exceeded the recommended value of 0.1 mg/l given by Hutt. This is not surprising since much of the drainage area contains both industrial and residential development. Land clearing activities have meant that no contiguous buffer strips are present to intercept any runoff. Both suspended solids and nutrients such as total P are expected to be high in such a situation.

Suspended solids levels in all streams were relatively low, and most stations sampled were below the CCREM guideline for no harmful effects to freshwater aquatic life (i.e. 25 mg/l).

Total dissolved solids (TDS) loadings in all watercourses sampled reflect the inorganic composition of influent water. Michael's Creek was the watercourse with the highest TDS loadings. This is due to the absence of buffer strips to intercept runoff from industrial and residential developments. The very high value in August at station #16 in Michael's Creek approached that found in brackish water (1001 mg/l, CCREM, 1987) and was expected because of the closing of the causeway gates after the last sample was taken in June. When the gates were closed, cutting off tidal influence, salt water became trapped behind the gates, therefore causing the TDS level to rise in freshwater areas such as the mouth of Michael's Creek.

An increase in DOC levels was noted in all watercourses in August and September. This may have been due to a pulse of humic substances coming from bog runoff water after a period of rainfall preceding both sampling runs. This precipitation followed very dry times throughout much of June, July and August.

Heavy metal concentrations (total) in all four sampling runs remained at or below receiving stream guidelines with the exception of aluminium (Al), iron (Fe) and zinc (Zn).

Aluminum tends to form complexes with tannins in runoff waters from the land. Although all stations had levels ≥ 0.1 mg/l which is above the guideline recommended by the CCREM, all concentrations were below the value of 1.5 mg/l recommended by Hutt. It is however important to note that aluminium concentrations in New Brunswick watercourses often exceed the recommended guidelines without posing a threat to aquatic life.

Although iron is a chemically non-toxic metal, it may precipitate and cause physical smothering of fish gill filaments or deposited eggs. During the first two sampling runs, iron values approached the CCREM guideline of 0.3 mg/l. During the August and September sampling runs, iron values in all watercourses exceeded the guideline value. However, even in the presence of high iron concentrations, no threat to any resident brook trout population is anticipated. This due to the action of chelating agents present in the stream and the absorption of iron into the sediment (iron is rendered unavailable for absorption by aquatic life). Both naturally high iron levels and some anthropogenic supplemental exports are expected in New Brunswick watercourses.

As with many other heavy metals, the toxicity of zinc to fish increases as pH and hardness decrease. Metals are generally more soluble and, thus, more biologically available at low pH. The listed limit for protection of aquatic life is 0.03 mg/l (CCREM). The only sample which clearly exceeded this level was taken at station #14 in Michael's Creek during the August, 1991, sampling run. As the pH value at this time remained above neutral, and considering that zinc concentrations obtained for this station during the other three sampling runs were near or below the guideline value, it is probable that a laboratory or sampling error occurred in the August sample.

Although cadmium (Cd) is not considered to be a problem in New Brunswick watercourses (J. Choate, per. comm., 1991), it is however highly toxic to fish because of its interference with physiological processes in the reproductive, skeletal, and excretory systems. The detection limit in the tests conducted was 10 ug/l and no stations exceeded this level. However, the upper limit guideline for aquatic life protection is 1.8 ug/l. In the future, more sensitive analysis should be attempted to accurately describe background levels.

Bacteriological testing for faecal and total coliforms (see Table 2-12) showed that Jonathan Creek, Somers Creek and the Cocagne River were acceptable for recreational purposes (e.g., swimming). Some stations in Michael's Creek and Shaw Brook did however surpass the guideline for faecal coliforms recommended by the CCREM.

2.4.3 RESULTS FROM PREVIOUS WATER QUALITY STUDIES

Exhibit 2-17 shows past and present surface water quality monitoring stations on the Petitcodiac and Cocagne watersheds. Previous water quality data collected from these stations are given in Table 2-13 (N.B.D.O.E., 1980 a, b, c, 1984).

Data collected from the Petitcodiac River Stations (N.B.D.O.E., 1980, a, b, c, 1984) between 1975 - 1979 showed surface waters in headwaters in either excellent (e.g. Total P < 0.05 mg/l) or good condition (e.g. Total P 0.05 - 0.1 mg/l). This would make them at least possibly suitable for swimming and a cold water fishery. Poor surface water quality (e.g. Total P > 0.1 mg/l, > 200 faecal coliform/100 ml water, < 5.0 mg O_2/l) existed at and sometimes below the Petitcodiac River causeway on the main river. The same studies (N.B.D.O.E., 1980 a, b, c, 1984) also indicated poor water quality in Jonathan Creek and its tributaries. No past data was available for any of the other watercourses included in this study. However, from maps provided in the previous studies, the mouths of both Somers and Michael's Creek were also assumed to have poor water quality (N.B.D.O.E., 1980 b).

Poor surface water quality in Jonathan Creek and the Petitcodiac River below the causeway (Table 2-13) was primarily the result of a lack of sufficiently operational sewage collection and treatment facilities for the Greater Moncton Area.

Exhibit 2-17 Past surface water quality monitoring stations for the Petitcodiac Basin Area and Eastern Shore Areas of New Brunswick and the locations of the three (3) potential sites (a, b, and c) for the Westmorland / Albert Integrated Waste Management Facility (I.W.M.F.)

SURFACE WATER QUALITY MONITORING STATIONS:

EARLIER STUDIES: • 1954 to 1986 Environment Canada
□ 1975 to 1979 N.B.D.O.E.

POTENTIAL I.W.M.F. SITES:
a, b, and c

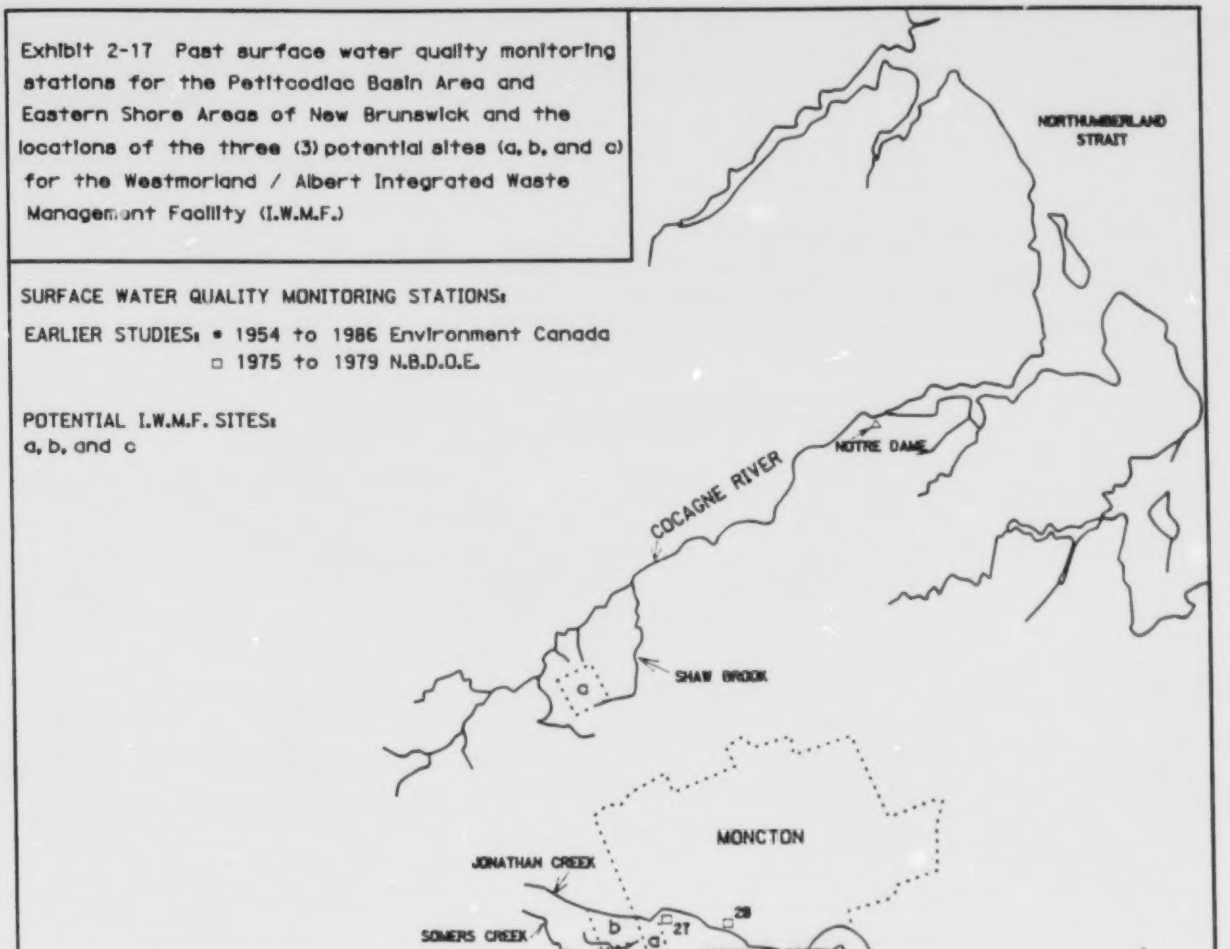

NORTHUMBERLAND STRAIT
NOTRE DAME
COCAGNE RIVER
SHAW BROOK
c
MONCTON
JONATHAN CREEK
SOMERS CREEK
b
a
27
29
MICHAEL'S CREEK
7&8
4
CAUSEWAY
14
5
SALISBURY
9
13
10
11
31
12
PETITCODIAC
HILLSBOROUGH
00
PETITCODIAC RIVER
1
2
3
4
5
6
(C)
FOX CK
MILL CK
MUD CK
7
8
9
10
11
12
STONEY CK
13
00
14
15
1978 STUDY
MONTREAL ENGINEERING
0
5
10 km

TABLE 2-13

MEDIAN WATER CHEMISTRY VALUES FOR STREAMS ADJACENT TO PROPOSED WASTE MANAGEMENT FACILITY SITES (A) DELONG DRIVE SITE, (B) BERRY MILLS ROAD SITE, AND (C) ROUTE 126 SITE

PARAMETERS [MEDIAN]	N.B.D.O.E. STATIONS										ENVIRONMENT CANADA STATIONS		
	PETITCODIAC RIVER								JONATHAN CREEK		PETITCODIAC RIVER		
SAMPLE SITE •	•7	•8	•9	•10	•11	•12	•13	•14	•27	•28	•4	•5	•31
NO. OF SAMPLES TAKEN	6 (1975-79)	5 (1975-79)	5 (1975-79)	3 (1975)	3 (1975)	3 (1975)	13 (1975-79)	12 (1975-79)	20 (1975-79)	17 (1975-79)	71 (1970-78)	48 (1954-74)	142 (1971-86)
pH	6.7	7.3	7.4	7.1	7.3	7.3	7.0	7.1	7.0	7.0	7.0	7.0	n.a.
Specific Conductance µs/cm	1770	360	180	346	325	496	188	180	160	120	117	121	n.a.
Alkalinity (mgCaCO3/l)	122	1240	40	88	84	134	100	74	53	59	27.5	31.8	n.a.
Nitrate - Nitrite (mg/l)	<0.01	0.343	0.03	<0.01	0.018	0.022	<0.01	0.60	0.22	0.17	0.095	0.100	n.a.
Total P (mg/l)	1.90	1.22	0.091	0.062	0.092	0.07	0.10	0.046	0.30	0.10	0.135	0.06	n.a.
T.O.C. (mg/l)	75.0	12.0	6.5	10.0	11.0	10.0	13.3	13.5	11.0	9.0	6.8	4.5	n.a.
[O2] (mg/l)	8.0	9.0	10.0	n.a.	n.a.	n.a.	n.a.	9.0	10.0	10.0	12.0	13.2	n.a.
Faecal Coliform •/100mL	3005	750	24	n.a.	n.a.	n.a.	58	40	760	190	n.a.	n.a.	n.a.
Cadmium (Cd) (mg/l)	<0.01	n.a.	n.a.	n.a.	n.a.	n.a.	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.001
Copper (Cu) (mg/l)	0.02	n.a.	n.a.	n.a.	n.a.	n.a.	<0.01	<0.01	0.01	<0.01	<0.002	0.02	<0.001
Iron (Fe) (mg/l)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.170	0.340
Mercury (Hg) (mg/l)	0.0001	n.a.	n.a.	n.a.	n.a.	n.a.	<0.0001	<0.0001	<0.0001	<0.0001	<0.05	0.13	0.17
Lead (Pb) (mg/l)	<0.1	n.a.	n.a.	n.a.	n.a.	n.a.	<0.1	<0.1	<0.1	<0.1	0.004	0.006	0.002
Zinc (Zn) (mg/l)	0.05	n.a.	n.a.	n.a.	n.a.	n.a.	0.09	0.04	0.04	0.06	0.009	0.013	0.009

SOURCE: N.B.D.O.E. 1980 a, b; 1984

Completion of the final phase of the Greater Moncton primary sewage treatment facility by 1993 should serve to improve water quality in the Petitcodiac River. By then, the number of outfalls discharging into this watercourse will have dropped from 60 to 1. This single outfall will be at Outhouse Point.

2.5 Biological Setting

2.5.1 TERRESTRIAL BIOLOGY

Terrestrial biological resources have been evaluated by reviewing available data on the potential sites, discussions with resource managers and their staff (e.g. T. Pettigrew, Regional Biologist; E. Masters, Chief Forest Ranger, Moncton Office), and site visits in November and December, 1990, by staff employed by ACI Limited.

2.5.1.1 Topography

The Delong Drive Site is gently sloping. The elevation drops from 59 m at the northern part of the proposed site to 42 m at Delong Drive, a grade of approximately 1%.

The Berry Mills Road Site is also gently sloping (approximately 1.4%) with an elevation of 65 m at the northwest corner of the site and 45 m at the southern boundary along the N.B.E.P.C. line.

The Route 126 Site is again relatively gently sloping (approximately 1.6%) with some flat and boggy areas in the southern half and the south central portion of the site. The elevation is 100 m at the northern half of the site and this rises up to 125 m at the southern portion of the site along the proposed access road.

2.5.1.2 Forest Stand Descriptions

Forest stand descriptions were based on Forest Development Survey maps on file with the Lands Branch at the Department of Natural Resources and Energy (Sites A and B - maps #6247, 6237, 6248, and 6238; Site C - maps #6245, 6345, 6246, and 6346). These maps from 1982 aerial photographs and revisions in 1986 and 1987 respectively were adjusted after site visits. Adjustments were based upon estimates of newly cut areas, major canopy species and stand maturity (i.e. regenerating, immature, mature, and overmature). Results are summarized in Table 2-14 and are recorded in Exhibits 2-18 and 2-19. Additional information on habitat suitability for deer was obtained by reviewing a 1:50,000 topographic map used by N.B.D.N.R.E. personnel during a 1989 aerial transect survey.

Delong Drive Site (Site A)

Much of the southern and western portions of this site have been clear cut.

East of the current access road, white birch, spruce and balsam fir are found halfway up to the N.B.E.P.C. line. South of this line, poplars and white birch are common.

All three species have many individuals (that form the canopy) with breast height diameters <20 cm. This is typical of both sites A and B.

Berry Mills Road Site (Site B)

White birch and spruce dominate the northern section in non-clear cut areas. Poplars, white birch, balsam fir and red maple exist behind the speckled alder thicket that follows Jonathan Creek.

The central and southern portions are clear cut, and contain some black spruce (which may be merchantable for pulp wood) at the cut edge.

The western section is dominated by grey birch and poplar trees.

Route 126 Site (Site C)

Spruce predominates at the northern edges of the clear cut area (see Exhibit 2-19). In this cutover portion of the site, balsam fir and white spruce saplings <3 m tall predominate. White pine seedlings are also scattered throughout the site. The length of the access road now on the site is traced by cat tails, reeds, and red maple pucker brushes or suckers.

The northern half of the site is a mixed wood stand containing spruce and both tolerant and intolerant hardwood stands.

2.5.1.3 Wetlands

Wetlands were evaluated by comparing field observations and ground cruise data recorded in Exhibits 2-18 and 2-19 with wetland maps on file with the Fish and Wildlife Branch of the Department of Natural Resources and Energy. The map pertaining to the Delong Drive and Berry Mills Road Sites is entitled "N.B. - 119 Salisbury - Berry Mills" and is based upon a November 1979 revision from 1976 photos. The map that corresponds to the Route 126 Site is entitled "N.B. - 109 Indian Mountain - Canaan Station - Saint Paul". It is based upon a July 1978 revision from 1976 photos.

TABLE 2-14

Forest stand descriptions for proposed sites
based on New Brunswick Forest Development Survey maps (4311 ha)
and ground cruises in December, 1990 & January, 1991

TREE SPECIES AND SUCCESSIONAL STAGES	SITES (NO. OF HECTARES)		
	Delong Drive Site	Berry Mills Road Site	Route 126 Site
SOFTWOOD [SW] (i.e. volume ≥ 90%)			
Spruce & other ssp; Immature/old*	15	51	46
Other spp.; Immature/old	13	2	0
Regenerating Stand (R)	0	13	0
Spruce & other spp.; Mature	0	0	7
Other spp.; M	0	0	1
MIXED WOOD (SW ≥ 70% of volume)			
SW - intolerant HW; I	30	5	30
SW - tolerant HW; M	0	0	19
MIXED WOOD (SW ≤ 30% volume)			
iHW (>50%) tHW (<20%) - SW; I	7	5	43
HARDWOOD [HW] (i.e. volume ≥ 90%			
iHW; I	89	65	5
iHW - tHW; I	2	1	6
iHW; M	10	0	0
CLEAR CUTS (iHW; R for avifauna excluding ruffed grouse)	36	144	109
Alder Swamps and Streams	6	40	7
	208 ha	**326 ha**	**273 ha**

*** i.e. two levels present in the stand**
iHW - stands composed of at least 60% poplar, white, and grey birch
tHW - stand of maple

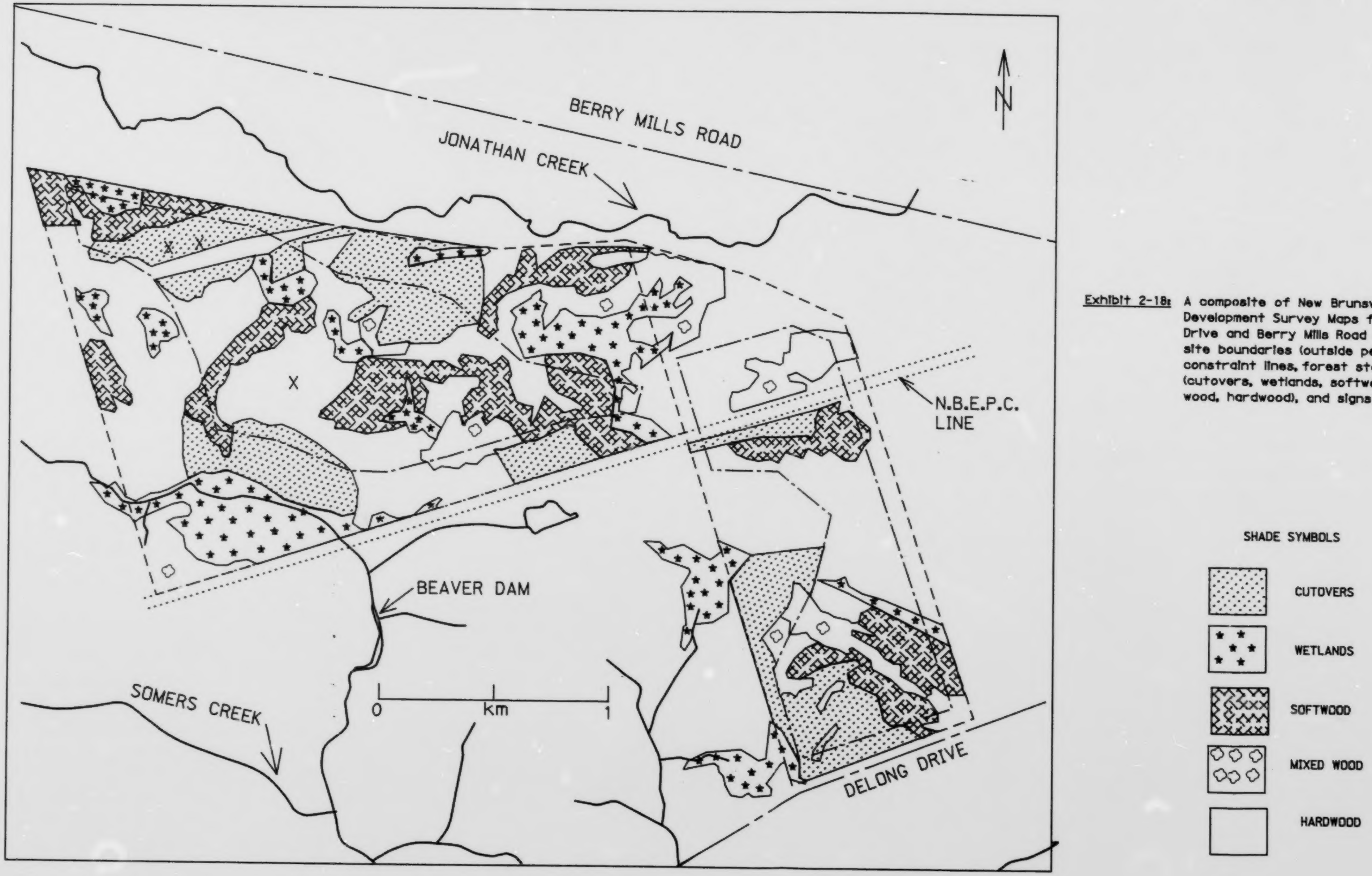

N
BERRY MILLS ROAD
JONATHAN CREEK
X X
X
N.B.E.P.C.
LINE
BEAVER DAM
0
km
1
SOMERS CREEK
DELONG DRIVE
SHADE SYMBOLS
CUTOVERS
WETLANDS
SOFTWOOD
MIXED WOOD
HARDWOOD

Exhibit 2-18: A composite of New Brunswick Forest Development Survey Maps for the Delong Drive and Berry Mills Road Sites showing site boundaries (outside perimeter) and constraint lines, forest stand types (cutovers, wetlands, softwood, mixed wood, hardwood), and signs of deer (X).

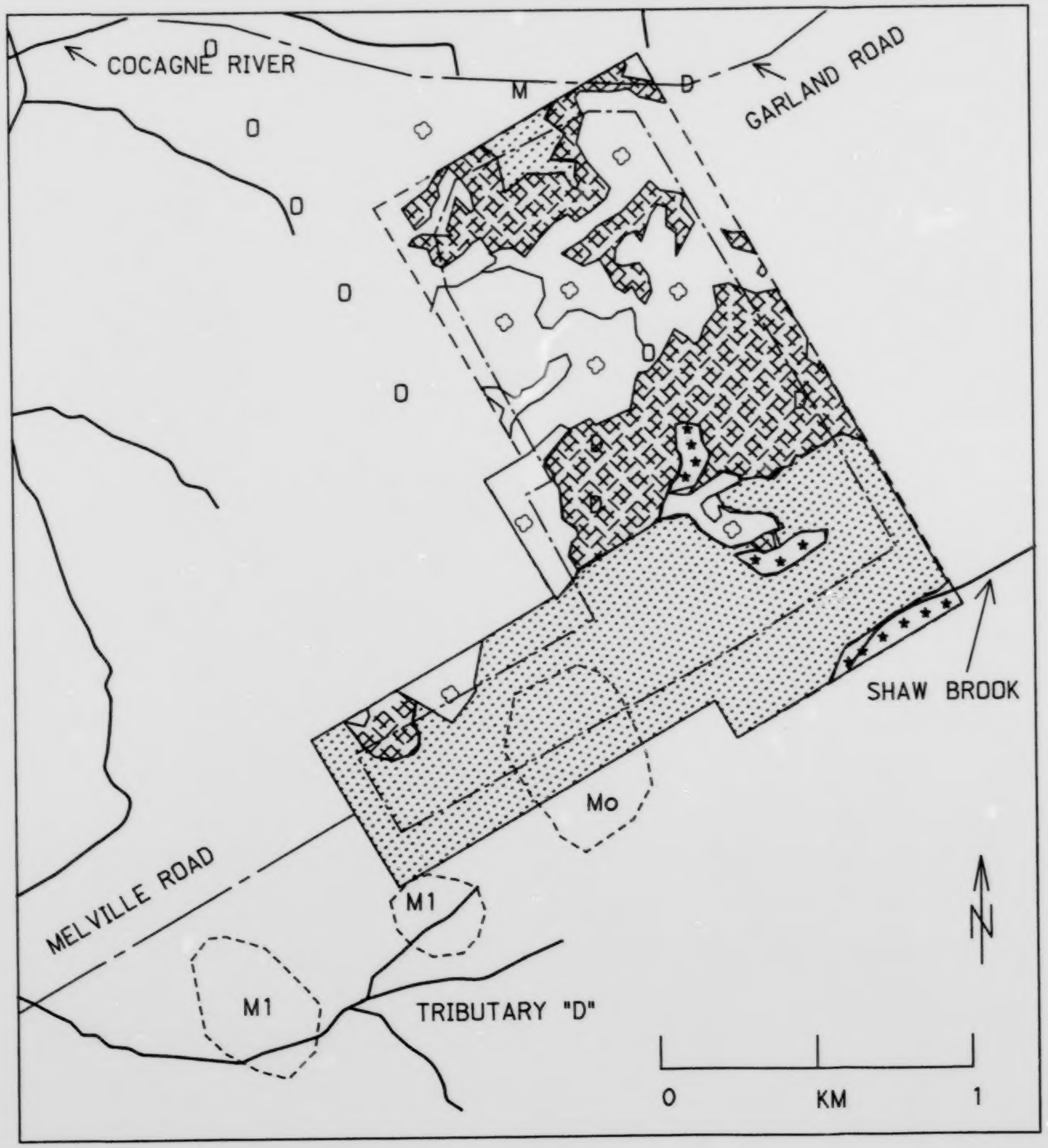

COCAGNE RIVER
GARLAND ROAD
SHAW BROOK
MELVILLE ROAD
TRIBUTARY "D"
Mo
M1
M1
M
D
O
N
0
KM
1

EXHIBIT 2-19: A composite of New Brunswick Forest Survey Maps for the Route 126 Site showing site boundaries (outside perimeter) and constraint lines, forest stand types (cutovers, wetlands, softwood, mixed wood, hardwood), moose signs (Mo) and wintering areas (M1) from 1989, moose signs (m) from 1991, and deer signs (1989: "O"; 1991 - 91: "D").

SHADE SYMBOLS

- ▨ CUTOVERS
- ★ WETLANDS
- ▩ SOFTWOOD
- ✿ MIXED WOOD
- ☐ HARDWOOD

These maps delineate wetlands on the basis of the Golet Index. According to this index, an area's wildlife productivity and diversity are assigned a numerical value from 35 - 109 (i.e. 35 - 49 = Poor; 50 - 64 = Fair; 65 - 79 = Good; 80 - 94 = Very Good; 95 - 109 = Excellent).

It is also possible to group freshwater wetlands into eight (8) categories. These are as follows:

1. Open Water: 1 - 3 m deep;
2. Deep Marsh: 0.15 - 1.0 m of water over the land during the growing season. Emergent marsh vegetation is dominant. Surface and submergent vegetation is present in open areas;
3. Shallow Marsh: < 0.15 m water during the growing season;
4. Seasonally Flooded Flats: Are flooded to at least 0.15 m annually during the Fall, Winter and Spring;
5. Meadow: Meadow emergents are dominant. A 0.10-0.15 m water column is present during the late Fall, early Winter and Spring;
6. Shrub Swamp: Shrubs are dominant and patches of the soil are seasonally or permanently covered with 0.15 m of water;
7. Wooded Swamp: Trees grow in saturated soil;
8. Bog: Sphagnum is the dominant species.

Delong Drive Site (A)

A wetland area is located on the central western border of this site (Exhibit 2-18). It is described as being a cross between a shallow marsh (category 3) and a meadow (category 5).

A patch of wetland is also identified in the northwestern portion of the site. This patch is also a cross between a shallow marsh and a meadow, has a Golet score of 63.5, and covers an area of approximately 6.5 ha.

An 8.1 ha area of sphagnum bog is located on the southwestern border of the site. It has an assigned Golet score of 48.5.

Berry Mills Road Site

A 26 ha area of *sphagnum* bog is located in the eastern portion of the site (Exhibit 2-18). This area has a Golet score of 53.0.

Four patches of shrub swamp wetland (category 6) are found in the central and northern areas of this site. The total area is approximately 6 ha with a combined Golet score of 57.0.

Three patches of wetland area are recorded in the western and northwestern portions of the site. These patches are basically *sphagnum* bog, encompass approximately 4 ha and have been assigned a Golet score of 50.5.

In the southwestern corner of the site, outside the constraint line, a 16.2 ha area of wetland is described as being a cross between a meadow (category 5) and shrub swamp (category 6) and has a Golet score of 64.0.

Route 126 Site

This site only contains very small zones (i.e. approximately 7 ha) of wooded swamp (category 7), as well as *sphagnum* bog in much of the cutover area (Exhibit 2-19).

2.5.1.4 Fauna

Based on forest stand composition, stand maturity and canopy species composition and rankings, habitat suitability unit values were assigned to each site; these were based on Forest Development Survey Map sheets and site visits.

Habitat suitability units for different species were calculated by assigning importance factors based on stand maturity and dominant tree species present (see Table 2-14). For White Tailed Deer and Moose, the suitability units were based on values accorded for: i) deciduous browse and ii) winter shelter. The habitat suitability units were calculated using the following formulas:

White Tailed Deer habitat suitability unit =

$$\Sigma\ (i \times \#\text{ha in a stand}) \times 0.6 + \Sigma\ (ii \times \#\text{ha in a stand}) \times 0.4$$

Moose habitat suitability unit =

$$\Sigma\ (i \times \#\text{ha in a stand}) \times 0.7 + \Sigma\ (ii \times \#\text{ha in a stand}) \times 0.3$$

Winter shelter for deer and moose is defined according to stand maturity and species composition (i.e. dominant tree canopy species) data obtained from site visits and information printed on the corresponding FDS maps on file with the D.N.R.E. Lands Branch office. The most suitable wintering area consists of a mature stand with > 60% crown closure, followed by, in declining order of importance, overmature, old/immature, young/immature, and regenerating, cutover, burned or plantation areas. The best species composition consists of softwood (SW) (eg. hemlock, spruce and balsam fir), followed by SW-HW, pine, HW-SW, and HW (hardwood) stands. The ii values in the formulas shown above are based upon the observed stand types and sizes of the stand located inside the boundary of the proposed sites. The ii values or importance coefficients originate from a previously published matrix of successional stage vs dominant tree species composition of a stand. (WMS and Associates Ltd., 1990). Therefore, as an example, Habitat Suitability (wintering area) for a hypothetical 100 ha block with 5 different forest stand types inside the perimeter is calculated as follows:

[ii_1 x 10 ha of stand type a]
+ [ii_2 x 10 ha of stand type b]
+ [i_3 x 40 ha of stand type c]
+ [ii_4 x 30 ha of stand type d]
+ [ii_5 x 10 ha of stand type e]

This sum is then multiplied by a factor of 0.4 for deer and 0.3 for moose.

Deciduous browse availability coefficients (i values) differ from wintering area coefficients (ii values) although the form of the matrix (successional stage vs dominant tree types) is the same. The sum is multiplied by a factor of 0.6 for deer and 0.7 for moose. The basis for slightly different i values for deer and moose stems from observed dietary differences for these species.

The woody browse consumed by deer varies according to time of the year, area and age of the animal. In winter, mountain maple and white cedar from tolerant HW-SW stands are consumed. The mixed SW-HW stands in winter offer balsam fir and red maple. Fawns prefer willows while adults prefer maple, viburnum and sheep laurel. The diet changes when the availability of plant species changes. Ferns dominate the diet in early Spring. Herbs and woody browse are consumed later on. Fruits and herbacious aquatic plants probably comprise much of the summer diet. Apples and beechnuts are favoured in the fall (WMS and Associates Ltd., 1990).

The winter diet of moss is similar to that of deer. It includes willows, balsam fir, trembling aspen, hazel, pin cherry, and maple. In summer, in New Brunswick, moose show a strong preference for rooted aquatic plants such ar pond lilies (personal observation, T. McEachreon).

In order to keep the equation for total habitat suitability relatively simple, quantitative estimation was restricted to two variables (stand age and species composition). The formulas used here were previously applied in a forest evaluation study done for large tracts of land (> 40 km^2) for another proposed development in New Brunswick (WMS and Associates, 1990). However, the principle of obtaining a precise and quantitative measure of total habitat suitability remains the same. Other important habitat components which may have been considered for moose, for example, include bogs for calving area, proximity to water for aquatic vegetation, relief from summer heat, and protection from stinging insects (R. Currie and G. Redmond, per. comm., 1991). The only suitable calving area among the three possible sites is at the Route 126 Site (see Exhibit 2-19). The most abundant wetland resources for ungulate summer diet items (eg. aquatic vegetation) are also north of the Route 126 Site on the Cocagne River and to a larger extent in the Bailey Brook headwaters according to the FDS maps.

The habitat suitability ratings for deer and moose assigned for each of the proposed sites are listed in Table 2-15. It has been assumed that for an entire FDS map sheet (~ 4000 ha) there are 3500 total habitat suitability units available (WMS and Associates, 1990). This translates to a maximum of 0.875 units/ha. (eg. A 273 ha site has a maximum habitat suitability rating (HSR) of 240). The numerical codes and the % value of the site specific maximum HSR shown in Table 2-15, general observations made during site visits, and a review of earlier data (eg. DWA + MWA aerial transects in 1989 for Region 3) lead to the conclusion that the most diverse wildlife habitat now present among the choice of three possible sites is at the Route 126 Site.

The marten importance factor coefficients (iii values) for each group of stands within a particular site are also based on successional stage vs species composition. Mature or overmature softwood stands of spruce-balsam fir have the highest coefficient value (i.e. 1.0). Young/immature mixed stands (SW-HW) have an intermediate value (eg. 0.5). Young/immature mixed stands (HW-SW) have a relatively small coefficient of importance (eg. 0.25). Regenerating stands of any species composition, cutover areas, and plantations do not increase the habitat suitability rating for marten. The entire marten specific matrix of successional stage vs species composition is presented in detail by WMS and Associates Ltd., 1990.

In order to calculate the habitat suitability ratings for Marten and Ruffed Grouse, the following formulas were used:

Marten habitat suitability unit =

Σ (iii x #ha in a stand type a in the site), where iii = Marten importance coefficients

Ruffed Grouse habitat suitability unit =

> Σ (iv x #ha in a stand type a in the site), where iv = Ruffed Grouse importance coefficients

Ruffed grouse habitat suitability matrix is also illustrated by WMS and Associates Ltd., 1990. The principle is the same as that which was used for marten.

TABLE 2-15

Current habitat suitability ratings for valued terrestrial ecosystem components potentially influenced at the proposed sites. Values are based on site size (i.e. 0.875 units per ha) and forest stand composition (maturity state and canopy species) from map interpretation and site visits. The % values represent the habitat suitability value as a portion of the maximum achievable value for the stand (eg. Route 126 Site: Deer; 106.26/240 = 44.28%).

RATING	Delong Drive Site 208 ha	Berry Mills Road Site 326 ha	Route 126 Site 273 ha
Excellent	136 - 180	214 - 284	181 - 240
Good	91 - 135	143 - 213	121 - 180
Fair	46 - 90	72 - 142	61 - 120
Poor	0 - 45	0 - 71	0 - 60
White Tailed Deer	F 65.58 (36.43%)	F 124.06 (43.68%)	F 106.26 (44.28%)
Moose	F 70.16 (38.98%)	F 138.72 (48.85%)	F 111.02 (46.26%)
Marten	P 30.75 (17.08%)	P 30.25 (10.65%)	F 75.25 (31.35%)
Ruffed Grouse	G 126.70 (70.39%)	F 106.50 (37.5%)	F 65.10 (27.13%)
Forest Avifauna	G 125.05 (69.47%)	F 129.28 (45.52%)	G 144.93 (60.39%)

Forest avifauna (46 species composed of raptors [4 sp.], woodpeckers [5 sp.], flycatchers [5 sp.], corvids and kinglets [9 sp.], vireos and warblers [13 sp.], sparrows [4 sp.] and finches [6 sp.] were included in the analysis of habitat suitability, given the forest stand types present within the borders of the three possible waste management facility sites. Based on previous studies (WMS and Associates Ltd., 1990), scores were assigned to 18 stand types, i.e. age (regenerating [R], maturing-seral [I], and mature [M]) and dominant species group (spruce-fir, other SW, mixed [SW-HW], mixed [HW-SW], tolerant HW, intolerant HW). These habitat importance scores were then ranked from 1-10. The number of bird species expected in each of the stand types was allso recorded, and the corresponding values were also ranked from 1-10. The actual importance coefficients (v values) were calculated as follows:

$$v = \frac{\text{(habitat importance rank + species rank)}}{20}$$

Finally, the forest avifauna habitat suitability units are defined as:

$$\Sigma\ (v \times \#\text{ha in a stand})$$

for all stands within proposed site borders.

For use by deer and moose as wintering areas, the optimum condition is a location where the stand is mature, of mixed wood (i.e. spruce and hardwood species), has more hardwood buds available for browsing, and a crown closure of 60% or more. The Delong Drive Site is not suitable for a wintering area but part of Berry Mills Road Site could sustain deer in winter. The Route 126 Site has the greatest potential for use by deer and moose even though the southern part has been cut over. This could change if the balance of the site were harvested at a later date. Definitive plans by the licensee for this part of Westmorland County will not be published until the 5 year and 25 year Management Plans (i.e. 1993-1998 and 1993-2018) are submitted in the spring of 1992. At present, no plans have yet been tabled to cut the balance of the Route 126 Site. Browse availability is greatest around the perimeter of the Route 126 Site and adequate winter shelter is now present in the central and northern portion of the site.

None of the potential sites are now known to contain rare, threatened or endangered species. No critical natural areas described for Westmorland County (Dionne et al., 1988) are found within or in close proximity ($\leq$ 25km) to any of the three sites. These conclusions are based on general observations made during site visits in December 1990 and April-August, 1991 and a review of other documents that examined rare, threatened, or endangered wildlife species in N.B. and the rest of Canada (Keith, 1990; Burt and Grossenheiden, 1976; Peterson, 1976; WMS and Associates Ltd., 1990).

Endangered species in Canada are described as resident species which face extinction or removal from a significant portion of their range because of human actions that destroy habitat. Examples in New Brunswick include the eastern cougar, Canada lynx, bald eagle, osprey, and the peregrine falcon (subspecies anatum).

In regards to flora, only Furbish's lousewort has an "endangered species" designated description for New Brunswick. It is restricted to the Upper Saint John River Valley (Dionne et al, 1988) so it is not a relevant impact issue regarding the location of this landfill facility.

Threatened species are indigenous populations that will become endangered if conditions are not improved. Two examples are recognized in New Brunswick. These are the peregrin falcon (subspecies tundrius) (Keith, 1990) and the gray-cheeked thrush (G. Redmond, per. comm., 1991).

Rare species are those that are existing at the outer limits of their range and are existing in small numbers or restricted areas in Canada. The only two examples that might apply to New Brunswick are the eastern bluebird and solitary sandpiper. Once again, if literature reports (eg. WMS and Associates, 1990) are insufficient to claim the non-presence of the eastern bluebird and solitary sandpiper at the three potential sites, an ornithologist will have to comment on the probability of there being breeding populations of these two species.

Delong Drive Site (Site A)

Numerous snowshoe hare tracks were found in the southern portion of the site. Deer and other terrestrial mammals will occasionally be found on this site, especially at the edges of cutover sections (see Exhibit 2-18). The use by deer is probably infrequent, given a lower end of the scale "fair" habitat suitability rating (Table 2-15).

Berry Mills Road Site (Site B)

At least two abandoned beaver dams were found east of the current access road on Jonathan Creek and one is located above aquatic sampling station #2A (see Exhibit 2-18). Mink may also be found on Jonathan Creek although none were seen.

Deer tracks were seen during the December-January ground cruises carried out for this study. However, no reports of active DWA exists for this site since 1982 (T. Pettigrew, R. Steeves, M.

Brown, per. comm.). A couple of tree stands in the northwest and central portion of the site, and one on the N.B.E.P.C. easement that is the southern border of the site, indicate that this location has been used at some time in the past by hunters.

In the northwestern corner of the site, in a stand of poplar and white birch, bird tracks were noted. These were assumed to belong to ruffed grouse because of the ambient forest stand. It consisted of a second growth deciduous (poplar and white birch) woodland at the edge of a cut.

The only reported deer wintering area in the vicinity was last decribed in 1982. It was a 21 hectare site and contained approximately 5 deer. It was not within the Berry Mills Road Site, but was located just north of the point where Somers Creek crosses Delong Drive. This is a small yard and no evidence has shown it to be an active one now. Put in context, an active deer wintering area of 21 hectares in this region in 1991 might be expected to contain 8-10 deer with up to 25 found in some places (R. Currie, per. comm., 1991).

Route 126 Site (Site C)

Both deer and moose wintering areas were noted in 1989 (Pettigrew, T., per. comm., 1991) (see Exhibit 2-19). Deer tracks were seen in the central portion of this site during ground cruises in 1990. Moose tracks were seen in late April of 1991 on the Garland Road.

In the quadrangle bounded by Route 126, the Cocagne River, the Victoria Road, and Indian Mountain Road, 13 points had signs of deer and 6 points had signs of moose. This is according to 10 aerial transect lines spaced approximately 810 m apart and completed by D.N.R.E. personnel in 1989. Three (3) of these points for moose signs were on the site or the access road and one (1) of the points for deer signs was in the central portion of the site (see Exhibit 2-19). The other 12 points for deer signs were to the north and east of the site.

In addition to the suitable wintering habitat (80 ha) on the Route 126 Site, other suitable wintering areas exist immediately to the east and west of the site, and to the north along the Cocagne River. For example, in a 193 ha section bordering the eastern boundary of the site, it is estimated from aerial transects (T. Pettigrew, per. comm., 1991) and data on FDS maps that 115 ha contain suitable deer wintering habitat. The tracts of land beside the upper reaches of Shaw Brook and to the east of the site could serve as deer wintering areas given the mature status and >50% crown closure of some stands. South of the Garland Road and to the east of the site, browse availability is estimated to be good. This is because of the presence of hardwood stands and the edge effect of mixed wood stands next to cut over tracts on private lots. Also, in an 81 ha block immediately west of the proposed Route 126 Site, about 65 ha contain suitable wintering habitat. It is estimated that north of the site and as far as the main Cocagne River, about 90 ha of suitable wintering habitat exist. Outside the outermost constraint lines as far west as Route 126, as far north as the Cocagne River and as far east as the Victoria Road, an additional 200 ha of suitable wintering area habitat exists. No suitable deer wintering areas have been identified south of the site between the Melville Road and Indian Mountain Road. Therefore, in the approximately 3300 ha between the Melville Road and the Cocagne River as far east as the settlement of Shaw Brook and as far west as Route 126 approximately 550 ha of suitable deer wintering area now exist.

In January, 1989, moose were spotted at 7 points between the New Scotland Road and Melville Road. Four (4) were >2 km to the east or north of the outermost constraint lines shown in Exhibit 2-19. Three (3) were in the vicinity of the Melville Road. Two of these are possible wintering areas. Further observations are needed to confirm this status. The "Mo" area of Exhibit 2-19 is not a wintering area. It may serve as a calving area for moose.

2.5.1.5 Waterfowl

The only regularly sampled location for breeding pairs of waterfowl is in Gallagher Ridge. This 25 km^2 block is west of Route 126 and encompasses both the mainstem and north branch of the Cocagne River. The counts approach those noted in most other blocks surveyed throughout New Brunswick. (Bateman, M. and Hanson, A. per. comm., 1991). No such breeding pair blocks are located within at least 5 km of the Delong Drive and Berry Mills Road Sites.

2.5.2 AQUATIC BIOLOGY

The primary focus of this section is fish habitat. The Federal Fisheries Act [34.(1)] defines this as spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes. Aquatic resources downstream of a proposed waste management facility site are valued ecosystem components.

2.5.2.1 Fish Habitat

Jonathan Creek contains two structures that eliminate upstream migration of fish from the Petitcodiac River; these are water level control structures at Main Street and St. George Boulevard, both below Centennial Park. Based on water quality considerations, no stable, non-migratory brook trout populations are expected below the location of station #4 on Jonathan Creek. Although parts of Jonathan Creek have been stocked in Centennial Park for "fish out" recreational purposes, no evidence of upstream migration is available. However, pockets of suitable salmonoid habitat do exist in the upper sections of tributaries emptying into the Petitcodiac Basin Area (Department of the Environment, 1984). Somers Creek, which crosses the south-west portion of the Berry Mills Road Site, may contain non-migratory brook trout. Michael's Creek, which is adjacent the Delong Drive Site, does not contain suitable habitat for salmon or brook trout. This is due to poor water quality caused by the many industrial activities which border Michael's Creek.

The Cocagne River, which is adjacent to the Route 126 Site, does contain suitable habitat for both brook trout and salmon (Richard, H., per. comm., 1991; Anthony, L., and Pettigrew, T., per. comm., 1990) (Tables 2-16 and 2-17). Although the Cocagne River is now being fished for brook trout, effort is described as being moderate by Conservation and Protection Officers familiar with the mainstem of the Cocagne River between the Victoria Road (Route 490) and Route 126. According to cruise reports from work done by a 17-person crew in the summer of 1989 about 34% of the Cocagne system adjacent to the Route 126 Site is suitable (i.e. "good" or "fair" according to Table 2-16) salmonoid rearing habitat. At least five salmon holding pools are located on the Cocagne's mainstem between Route 490 and Route 126.

While the Cocagne River is definitely the object of at least moderate fishing pressure no activity on either Somers Creek or Jonathan Creek could be confirmed.

Aquatic habitat loss might also be greatest on the Cocagne watershed. Shaw Brook, for example (Exhibit 2-16) was identified in 1974 as containing resident salmon and trout populations. Both species were found below the Victoria Road (Gallop, P., per. comm.). At that time, a stretch was identified (Exhibit 2-16) as having good potential as a nursery area. Good instream cover and shade were present on a section with both pools and riffle areas. Habitat classification according to Table 2-17 is considered satisfactory.

Although Department of Fisheries and Oceans fish habitat enhancement efforts have focused upon the Miramichi watershed, the Cocagne system is still considered to be part of a Region with a significant salmonoid production potential. Landings of other fin fish and shellfish in the corresponding Gulf Region fishing district support a hypothesis of valuable commercial fishery resources being present in the Cocagne system.

TABLE 2-16

Definitions and Criteria for Use in Salmonoid Habitat Classification

TYPE	POTENTIAL	FLOW RATE m/s	DEPTH m	SUBSTRATE
1	**Good**; for spawning, often some feeding pools for larger age classes	0.1 - 0.3 moderate riffles	0.3 - 1 shallow	gravel to cobble, some boulders
2	**Good**; limited spawning (i.e. isolated gravel pockets, good feeding & holding areas for larger fish in deeper pools, pockets or backwater eddies	0.3 - 1 heavier riffles, light rapids	0.3 - 1.5 variable	cobble/ rubble to boulders & bedrock; some gravel pockets
3	**Poor**; for rearing and spawning, used for migratory purposes	1 very fast, rapids & small waterfalls	0.3 - 1.5 variable	boulders & bedrock
4	**Poor**; for juvenile rearing & no spawning capability; shelter & feeding area for larger older fish such as brook trout	0.15 sluggish	often 1 m variable	soft sediment, some boulders or bedrock, aquatic macrophytes in many locations
A	**Good** Potential as Nursery Area	"good" flow	≥0.6	rock, rubble, loose bottom material
B	**Fair** Potential as Nursery Area		0.3 - 0.6	rubble & small boulder
C	**Poor** Potential as Nursery Area	"slow" flow	<0.3	fine

Types 1-4 from Barnes, 1989.

Types A, B, C from J. Bleenis, per. comm., 1991

TABLE 2-17

Salmonoid Nursery Area Habitat Evaluation in 1989
on the Cocagne River System Tributaries Adjacent to a
Proposed Integrated Waste Management Facility

STREAM	# STREAM KM			TOTAL #M STREAM HABITAT	PRODUCTION AREA ASSESSMENT (M^2)				M^2 NON-PRODUCTIVE AREA
	TOTAL	MAIN STEM	# SURVEYED		GOOD	FAIR	POOR	TOTAL	
Cocagne (main)	57.7	20.6	32.03	365,769.05 %	37,130.93 10.15	90,774.98 24.82	87,855.63 24.02	215,761.54 58.99	150,007.51 41.01
Shaw Brook	3.6	2.6	3.60	13,563.63 %	169.55 1.25	537.97 3.97	2,683.39 19.78	3,390.91 25.00	10,172.72 75.00
Tributary "D"	0.5	5.2	0.50	1,815.32 %	72.61 3.99	145.22 7.99	508.27 27.99	726.10 39.97	1,089.22 60.03
Whole System	61.8	28.4	36.13	381,148. 100%	37,373.09 9.81	91,458.17 23.99	91,047.29 23.89	219,878.55 57.69	161,269.45 42.31

Source: T. Pettigrew, per. comm., 1991.

Since freshwater outflow is a very significant factor in ecological processes in temperate coastal waters that support reproduction in many important stocks, any additional perturbation or increase in stress to an estuarine system must be carefully considered. Based on the above catch statistics, the Cocagne system is more commercially important than the districts dependent on the Petitcodiac. It should therefore be viewed from a biological perspective as a less desirable site for the waste management facility than either of the two sites closer to the centroid of waste generation and the Petitcodiac system.

Thanks to cooperation from the Department of Fisheries and Oceans fish habitat researchers in Moncton, it was possible to perform spot checks for salmonoids on the Cocagne system in April of 1991. Such checks on Jonathan Creek and Somers Creek were also performed (September 1991) even though habitat management considerations in the Scotia-Fundy Region place these two watercourses in a low priority position.

The major determining factor at the present time concerning salmonoid population densities on the Petitcodiac River above the causeway is the length of time the gates remain open. Last year only eight (8) salmon moved upriver through the gates (Stewart, J., per. comm., 1991). This is a small step towards reestablishing a salmon stock here. If population enhancement is to progress, the gates will have to be permanently opened. Efforts to achieve this goal have been stepwise. Vigorous debate and study programs continue on the subject of widening the river channel on both sides of the causeway. The headpond above the causeway remained drawn down this year until late June. This permitted movement upstream by anadromous species such as smelt and gaspereau. Federal fisheries managers and conservation staff remain hopeful that the gates will eventually be opened permanently. Salmonoid habitat improvement projects further upstream will then receive increased encouragement.

In addition to the water level control structures, the domestic waste discharges and other effluent sources below water sampling station #4, the presence of at least three beaver dams on Jonathan Creek between the border of the Delong Drive and Berry Mills Road Sites and station 2A obstructs fish movement. These dams tend to increase the siltation rate, warm the water, and change the aquatic fauna (e.g. a shift to tubificid oligochaetes or nematodes vs. caddis fly larvae). This means that the most optimistic rating Jonathan Creek would receive according to Table 2-16 and Table 2-18 is Type 2 or Type B. A large beaver dam south of the Berry Mills Road Site and the NBEPC line also means that the unnamed tributary of Somers Creek above the NBEPC line has a rating of Type 4. Below the beaver dam, the biggest threat to fish habitat on Somers Brook is improper cutting practices (i.e. lack of buffer strips parallel to either or both stream banks).

TABLE 2-18

Some Physical Parameters Pertinent to Assessing Salmonid Nursery Area Quality for Select Stream Sections on Watercourses Adjacent to Proposed Sites

Stream Characteristics	Jonathan Creek		Somers Creek		Cocagne River (Main Stem)	
	Station 2A	Station 3A	Station 6A	Station 9A	Station 18A	Station 19A
Section Length (m)	40	40	40	40	30	30
a. Av. Section Width (m)	5.29	5.20	3.08	2.74	11.13	12.01
b. Av. Section Depth (m)	0.31	0.20	0.24	0.26	0.74	0.485
c. Stream Velocity (m/s)	0.36	0.69	0.44	0.39	0.59	1.16
Flow (m^3/s = abc*	0.59	0.72	0.33	0.28	4.86	6.76
Substrate (%):						
Sand and finer gravel	15	10	5	10	50	25
(0.3 - 7.6 cm)	40	20	20	25	0	20
Cobble (7.6 - 30.5 cm)	35	40	70	60	15	40
Boulders (>30.5 cm)	10	30	5	5	25	10
Rock ledge or hardpan			0	0	10	5

* See formula in Vromans, 1988 (Appendix "D")

2.5.2.2 Electrofishing Results

Since salmonoids (Altlantic salmon and brook trout) were assumed to be the most important species that could be most influenced by the Integrated Waste Management Facility, field investigations were done to verify their presence in the Cocagne River, Jonathan Creek, and Somers Creek. These electrofishing spot checks were designed to provide baseline data for comparison with more extensive quantitative sampling to be completed during post-construction monitoring. The fish collected were returned to the stream alive after one complete zig-zag sweep through two (2) stream sections for each of the three (3) streams investigation.

Lengths and numbers of all fish captured during the electrofishing are given in Appendix F.

Cocagne River

On April 23, 1991, a three person crew sampled station #19A on the Cocagne River; an area of approximately 100 m^2 was covered. An attempt to sample station #18A was also made.

At station #19A, small pools below low head barriers (i.e. fallen trees and riffle areas, and sandy portions under snow and ice covered banks) were checked by the backpack electrofisher operator.

Only one fish, possibly a salmon or a trout, was detected. The fast flow of the water at that time contributed to the escape of that individual.

Excessively high water levels at station #18A on April 23, 1991, prevented electrofishing spot checks from being made.

Jonathan Creek

On September 19, 1991, stations #3A and #4 were sampled; an area of approximately 100 m^2 was covered for each station. These stations were obvious choices for electrofishing since, at most times during the summer, at least three species of fish can be seen schooling in the pools near the stations.

At station #4, the large pool (immediately below the Route 128 culvert) was too deep (i.e., > 1.5 m) to sweep completely; therefore, only the lower half of its circumference was skirted by the two-person crew carrying out the electrofishing work. While this pool is a suitable feeding area for larger age classes, some portions of the Creek below this pool contain gravel areas where limited spawning success by brook trout previously placed into the system at Centennial Park can be expected.

A total of eight (8) species were captured at both stations, including brook trout. White suckers captured at station #3A were much larger than those captured at station #4. Another observation made was that creek chub encountered at station #4 seem to have contracted fungal infections; black spots on the sides may be fungal hyphal. Microscopic examination is required to confirm this.

Somers Creek

On September 19, 1991, stations #6A and #11 were sampled; an area of approximately 100 m^2 was covered for each station.

There are virtually no pool areas on Somers Creek from station #9A to #10 or station #5 to #6A (Exhibit 2-15). Above the N.B.E.P.C. line that intersects Delong Drive, the stream bed is very prone to drying up and, at several points instream, obstructions (sediment deposits and tree branches) intercepted what little flow of water did occur in the summer of 1991.

At station #6A, the instream cover provided by the buffer strip of older bushes on either side of the stream banks does much to maintain the current habitat suitable for the minnows and eels found at this site. No suitable spawning area for salmonoids were identified.

At station #11, a total of five (5) species of minnows were captured. This station is located in a soft sediment area. Micro algae (possibly Cladophora) was apparently in a bloom stage of development at the time of electrofishing, and anoxic conditions seemed to exist in the sediment. This conclusion is based on the dark brown-black appearance of the sediment in some places after it was disturbed by the field workers. A rotten egg odour also arose from the sediment after physical disturbance.

Based on the qualitative electrofishing spot checks performed, the entire lower portion of Somers Creek (station #11 to the Petitcodiac River) is considered to be marginally suitable as a shelter and feeding area for trout.

2.5.2.3 Benthic Invertebrates

Benthic Invertebrates were also sampled qualitatively on a presence/absence basis with a modified kick sampler. This simple but effective device consisted of a 2 m wooden handle attached to a coarse sorting net (2 cm mesh) and a 25 cm x 17 cm minnow dip net (<500 um mesh diameter). At five locations along 30-40 m sections of stream (i.e. Stations #2A, 3A, 6A, 9A, 18A, 19A), the sampler was placed flush with the bottom and "kicks" were made to qualitatively sample an area of 400-600 cm^2 (0.05 m^2). Results are summarized in Table 2-19.

Project objectives and available resources are important considerations when it comes to deciding upon the taxonomic level to which macro-invertebrates are identified. The major objective was to determine where potential salmonoid food such as caddis fly larvae was available. Identification of representative specimens from each site was followed to the taxonomic level of Family.

Jonathan Creek is dominated by invertebrates that are not usually linked with salmonoid diets. Although insects are present in the meandering stream portion of Somers Creek below the beaver dam (i.e. Stations #6A and #9A of Exhibit 2-15), the greatest diversity present is in the mainstem of the Cocagne River.

2.6 Socio-Economic System

2.6.1 DEMOGRAPHIC AND ECONOMIC STRUCTURE

2.6.1.1 Population

Table 2-20 presents the populations of Westmorland County and Albert County from 1971 to 1986. Table 2-21 calculates the percent change in population for each five year period. (The population of the Province over this period is provided for comparative purposes.)

The population of the Westmorland-Albert Region has increased from 114,976 to 135,801 (18 percent) over this 15 year period. The population of the Region experienced the majority of this growth (11 percent increase) during the period 1971 to 1976. The population has continued to increase since that period but at a reduced rate. The increase was 3 percent from 1976 to 1981 and an additional 3 percent from 1981 to 1986. It should be noted that the rate of growth of the region has been higher than the Provincial rate. The Provincial growth rate from 1971 to 1986 was 12 percent. The Region's population continues to grow faster than that of the Province (see Table 2-21).

TABLE 2-19

Group presence and abundance rank (P)* of major groups of benthic invertebrates encountered from 5 spot checks** at sampling stations on: Jonathan Creek, Somers Creek and the Cocagne River

Benthic Macro-invertebrates	Jonathan Creek		Somers Creek		Cocagne River	
	Station 2A (abundance)	Station 3A (abundance)	Station 6A (abundance)	Station 9A (abundance)	Station 18A (abundance)	Station 19A (abundance)
ARTHROPODA						
Insecta - Dipterous (true flies)						
Simulidae (black midges)	(1/5) P_1	(1/5) P_1	(4/5) P_4	(4/5) P_4	(0/5) P_1	(1/5) P_3
Chironomidae (midges)	(0/5) P_1	(3/5) P_3	(1/5) P_3	(3/5) P_1	(3/5) P_3	(2/5) P_1
- Trichoptera (caddis flies)	(2/5) P_1	(3/5) P_3	(3/5) P_3	(4/5) P_3	(0/5) P_1	(3/5) P_3
- Plecoptera (stone flies)	(2/5) P_3	(3/5) P_3	(3/5) P_3	(3/5) P_2	(0/5) P_1	(1/5) P_2
- Ephemoptera (mayflies)	(2/5) P_1	(1/5) P_3	(2/5) P_1	(0/5) P_1	(0/5) P_1	(2/5) P_3
- Coleoptera (beetles)	(0/5) P_1	(3/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(1/5) P_1
- Odonaeta (Dragonflies)	(1/5) P_1	(0/5) P_1	(0/5) P1	(1/5) P_1	(1/5) P_1	(1/5) P_1
NEMATODA						
- Species A	(3/5) P_3	(5/5) P_4	(0/5) P_1	(1/5) P_1	(1/5) P_1	(3/5) P_3
- Species B	(1/5) P_1	(0/5) P_1	(0/5) P_1	(1/5) P_1	(0/5) P_1	(2/5) P_1
- Species C	(0/5) P_1	(2/5) P_3	(0/5) P_1	(0/5) P_1	(0/5) P_1	(1/5) P_1
ANNELIDA						
Oligochaeta						
- Haplotaxida	(1/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1
- Lumbriculida	(2/5) P_1	(0/5) P_1	(1/5) P_1	(0/5) P_1	(0/5) P_1	(1/5) P_1
- Tubificidae	(1/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1
MOLLUSCA						
Gastropoda	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(0/5) P_1	(1/5) P_1

* Abundance ranks are as follows:

P_1 - group #s are $\leq$ 20 specimens/m^2
P_2 - group #s are 40-100 specimens/m^2
P_3 - group #s are 120-200 specimens/m^2
P_4 - group #s are > 200 specimens/m^2

This rank applies to at least 1 of the 5 samples taken per station.

** (2/5) indicates presence in 2 of 5 samples taken.

TABLE 2-20

Populations of Westmorland/Albert Region and New Brunswick 1971 - 1986

Location	1971	1976	1981	1986
Westmorland County	98,669	105,725	107,640	110,969
Albert County	16,307	22,159	23,632	24,832
Westmorland-Albert	114,976	127,884	131,272	135,801
New Brunswick	634,557	677,250	696,403	709,442

Source: Statistics Canada Census Publications

TABLE 2-21

Population Growth Rates of Westmorland/Albert Region and New Brunswick 1971 - 1986

Location	1971-76	1976-81	1981-86
Westmorland County	7.2%	1.8%	3.1%
Albert County	35.9%	6.6%	5.1%
Westmorland-Albert	11.2%	2.6%	3.5%
New Brunswick	6.8%	2.8%	1.9%

Source: Statistics Canada Census Publications

Comparing the two counties in terms of population growth, Albert County has experienced the larger percent increase throughout this period. The population of Albert County increased by 36 percent from 1971 to 1976, increased by 7 percent from 1976 to 1981, and increased by 5 percent from 1981 to 1986. The population of Westmorland County increased by 7 percent from 1971 to 1976, increased by 2 percent from 1976 to 1981, and increased by 3 percent from 1981 to 1986.

Populations and population growth rates of incorporated areas in the Westmorland-Albert Region are shown in Table 2-22. The most populated area in the Westmorland-Albert Region is the City of Moncton with a population of 55,468 in 1986. While the population of Moncton has been relatively stable over the last 15 years, the towns of Dieppe, Shediac and Riverview have been steadily growing.

The other major urban area, Sackville saw its population grow 2.9 percent from 1971 to 1976, but since then it has been decreasing. The majority of the villages in Westmorland County have shown positive growth rates for the period from 1981 to 1986, with the exception of the Village of Port Elgin. The villages of Albert County all have shown negative growth rates for the period from 1981 to 1986. Salisbury is the only village that has shown positive growth rates throughout the periods from 1971 to 1976, 1976 to 1981, and 1981 to 1986.

Table 2-23 presents the populations and population growth rates of parishes in the Westmorland-Albert Region. This data illustrates the recent trends in population growth in the rural areas of the Region. (The population figures for the parishes do not include the incorporated communities.) The population of the parishes of Botsford, Westmorland, Alma and Harvey all decreased for the period from 1976 to 1981; with Alma showing the largest decrease of 61 percent. For the period from 1981 to 1986 all Parishes had positive population growth rates. Shediac Parish and Moncton Parish were the most populated with Shediac Parish having a population in 1986 of 7,898 and Moncton Parish having a population of 7,274. Alma Parish was the least populated in 1986 having a population of 14.

The overall population projections developed for the Region are presented in Table 2-24. These projections have been prepared for the purposes of planning the development and operation of the landfill. The projections correspond to a high growth scenario to ensure that the landfill will be able to meet the Region's needs in the years to come. The population of the Region has been projected to increase from 135,803 in 1986 to 190,400 by the year 2014. This translates into an increase of slightly more than six percent every five years.

TABLE 2-22

Populations and Population Growth Rates of Incorporated Areas in the Westmorland/Albert Region

Location	Population Growth Rates (%)			Population
Westmorland County	**1971 to 1976**	**1976 to 1981**	**1981 to 1986**	**1986**
Moncton/City	2.0	-2.1	0.9	55,468
Dieppe/Town	12.8	14.1	6.7	9,084
Sackville/Town	2.9	-2.1	-2.9	5,470
Shediac/Town	15.4	1.7	1.9	4,370
Cap-Pele/Village	9.9	-6.5	1.8	2,261
Dorchester/Village	-6.2	-2.1	8.8	1,198
Petitcodiac/Village	12.1	-4.6	3.6	1,355
Port Elgin/Village	11.0	2.4	-6.7	470
Saint Joseph/Village	7.9	-15.0	5.6	665
Salisbury/Village	30.3	18.6	4.2	1,742
Albert County	**1971 to 1976**	**1976 to 1981**	**1981 to 1986**	**1986**
Riverview/Town	61.1	5.1	4.9	15,638
Alma/Village	-15.7	-1.5	-5.8	310
Hillsborough/Village	8.1	7.5	-2.0	1,214
Riverside-Albert/ Village	8.3	2.4	-9.6	432

Source: Statistics Canada Census Publications

TABLE 2-23

Populations and Population Growth Rates of Parishes in the Westmorland/Albert Region*

Location	Population Growth Rates (%)			Population
Parishes of Westmorland County	**1971 to 1976**	**1976 to 1981**	**1981 to 1986**	**1986**
Botsford	2.0	-1.0	0.8	3,014
Dorchester	3.9	4.4	0.8	4,786
Moncton	59.0	20.8	16.3	7,274
Sackville	19.1	0.7	1.1	1,216
Salisbury	14.2	9.6	10.2	3,479
Shediac	18.2	7.9	6.0	7,898
Westmorland	3.9	-0.4	7.8	1,193
Parishes of Albert County	**1971 to 1976**	**1976 to 1981**	**1981 to 1986**	**1986**
Alma	-3.4	-60.7	27.3	14
Coverdale	16.0	19.5	12.2	3,437
Elgin	3.6	9.1	6.3	933
Harvey	6.3	-10.4	2.9	494
Hillsborough	6.0	7.2	6.4	1,552
Hopewell	0.1	7.1	2.5	808

*Note: Parish population includes only the unincorporated areas.

Source: Statistics Canada Census Publications

TABLE 2-24

Westmorland/Albert Region Population Projections, 1994-2014

COUNTY	1986 CENSUS	1994	1999	2004	2009	2014
WESTMORLAND	110,969	122,000	129,200	137,300	146,000	155000
ALBERT	24,834	27,400	29,300	31,200	33,300	35400
REGION TOTAL	135,803	149,400	158,500	168,500	179,300	190,400

2.6.1.2 Socio-Economic Structure

The three communities that make up the Greater Moncton area, Moncton, Riverview and Dieppe, account for 59 percent of the Region's population. The rural population of the Region (those living outside the city, towns and villages) is 36,126 or 27 percent.

The Greater Moncton area is one of the Province's major urban regions and is an important communications, manufacturing and transportation centre for Atlantic Canada. There are four towns in the Westmorland/Albert Region. The Towns of Dieppe, Sackville and Shediac are located in Westmorland County and the Town of Riverview is located in Albert County.

Villages of the Westmorland-Albert Region include:

Westmorland County
- Cap-Pele
- Dorchester
- Petitcodiac
- Port Elgin
- Saint Joseph
- Salisbury

Albert County
- Alma
- Hillsborough
- Riverside-Albert

The economic structure of the region can be illustrated by the employment by economic sector. Table 2-25 summarizes the 1990 employment by sector for New Brunswick and the economic region of Westmorland, Albert and Kent Counties (The employment by sector is not available for the Westmorland/Albert Region. However, it is available for the economic region defined as the three counties of Westmorland, Albert and Kent.). Service industries is the most important sector for the region accounting for 34 percent of the employment or 23,900 employees. Other major sectors in the region

TABLE 2-25

Employment by Sector for 1990

Industry Divisions	New Brunswick		Westmorland, Albert and Kent Counties*	
Agriculture	4,000	1.4%	1,100	1.5%
Other Primary (mining, forestry, fishing etc.)	11,000	4.0%	2,600	3.7%
Manufacturing	31,000	11.2%	6,800	9.6%
Construction	18,000	6.5%	3,900	5.5%
Transportation/Communications & Other Utilities	29,000	10.5%	8,200	11.6%
Trade (Retail and Wholesale)	59,000	21.3%	15,300	21.6%
Finance/Insurance/ Real Estate	10,000	3.6%	3,000	4.2%
Service	95,000	34.3%	23,900	33.8%
Public Administration	20,000	7.2%	6,000	8.5%
TOTAL	277,000	100.0%	70,800	100.0%

*Note: A breakdown of employment by sector for Westmorland and Albert Counties only is not available.

Source: Statistics Canada Catalogue 71-001 include the trade industries (retail and wholesale firms) - 22 percent of employment or 15,300 employees, transportation/ communications and utilities - 11.6 percent or 8,200 employees, manufacturing - 9.6 percent or 6,800 employees, and public administration - 8.5 percent or 6000 employees. The agriculture industry accounted for less than two percent of employment and the other primary industries (primarily fishing, mining and forestry) accounted for almost four percent of the economy.

Agricultural activity in the Westmorland-Albert Region is generally centred around beef, dairy and hog farming, however, agricultural activities are expanding through the utilization of fruit and vegetables. Most of the agricultural products are processed locally. Thus, food processing is an important part of the local manufacturing sector.

The major non-agricultural primary industries, include fishing, forestry and mining. Commercial saltwater fishing is of prime importance to the regional economy. Lobster, crab, scallops, mackerel and groundfish are all harvested and processed in the local coastal communities. Industrial minerals mined and quarried include sandstone, granite, limestone and gypsum. The forestry sector includes the operation of timber lands and lumber mills.

Manufacturing includes industries involved in food processing, wood, metal and plastics fabrication.

The profile of the region with respect to employment by sector is very similar to that of the Province (see Table 2-25). The Region is slightly more involved in the transportation/communications industries and public administration. These are offset by less reliance on manufacturing, and construction.

2.6.2 LAND USE AND RESOURCES

2.6.2.1 Land Use and Ownership

This section summarizes the current land use and ownership along with the future land use alternatives for the three sites under consideration.

Delong Drive Site

This 212 hectare site is located on Delong Drive across from the CN Humpyard. This parcel of land is part of a large block of wood land located west of the Moncton Industrial Park, between Berry Mills Road and the Salisbury Road. Access would likely be gained from Delong Drive but could also be gained from the Berry Mills Road.

The property is privately owned, as is most of the property in the area. The site is forested, however, most of the merchantable timber was recently removed. There has been no development of the site in terms of buildings or services, nor are there any immediate plans to develop the site other than as a waste management facility. The property, along with the other land in the immediate area, is being held awaiting future industrial development.

The major land uses in the general area are the industrial park (1.5 km from site), the CN humpyard (directly across Delong Drive), CN rail line to Campbellton (northern boundary of the site) and other industrial operations at the intersection of Berry Mills Road and Edinburgh Drive. The nearest residential development is north of Berry Mills Road at the intersection of Horsman Road and the Old Ryan Road (1.1 km). There is also a small residential sub-division north east of the site on Zack Road (2 km).

The current zoning of the site and the adjoining properties is RA (rural agricultural) except for a 150 m strip along Delong Drive which is zoned light industrial. The current municipal land use plan specifically identifies the area as a suitable location for a sanitary landfill operation.

The site has limited potential in terms of resource development. The site is not attractive for agriculture uses given its limited potential and cost for development. The previous sections have established that the aquatic and wildlife use is limited and it is not considered a priority area for habitat enhancement. The existing forestry resources are also minimal small due to recent logging operations. Over time, the site could be re-forested for pulpwood or saw logs. The current adjacent land uses are not compatible with any type of residential development.

The most likely future land use alternatives would be related to industrial development similar to that occurring in the Moncton Industrial Park and along Berry Mills Road. However, the development of the site for industrial purposes does not appear imminent considering the availability of serviced industrial land in the adjacent industrial park and elsewhere in the greater Moncton area. Furthermore, the development of the site as a waste management facility would not be seen as a deterrent to industrial development in the area nor to future expansion of the industrial park.

Berry Mills Road Site

This 324 ha site is adjacent to the Delong Drive site and could be accessed from Berry Mills Road or Delong Drive. This site is also privately owned and is similar to the Delong Drive site in terms of current land use and suitability for development as a waste management facility.

The major land uses in the area are the same as those mentioned for the Delong Drive Site. These include the industrial park (2.5 km from site), the CN humpyard (Delong Drive), CN rail line to Campbellton (northern boundary of the site) and other industrial operations near the intersection of Berry Mills Road and Edinburgh Drive. The nearest residential development is north of Berry Mills Road on Zack Road (1.4 km).

The zoning of the site and the adjoining properties is RA (rural agricultural). The Municipal Land Use Plan for the Greater Moncton Planning District permits a public facility such as the proposed waste management facility in the area.

The future land use alternatives for this site are similar to the Delong Drive Site. This site has little or no agricultural, residential, aquatic or wildlife potential. The forestry potential is small given its lack of merchantable timber. Re-forestation would be a possible alternative but appears unlikely.

The real alternative land uses to the proposed waste management facility would be related to industrial development similar to that occurring in the Moncton Industrial Park and along Berry Mills Road. However, the development of the site for industrial purposes is generally less attractive than the Delong Drive Site due to the increased cost for road access and other services. Again, it is not expected that the development of the site as a waste management facility would be seen as a deterrent to industrial development in the area nor to future expansion of the industrial park.

Route 126 Site

This 280 ha site is a small portion of the Provincial Crown lands in the area north of Moncton. The site is approximately 2 km from Route 126. The southern part of the site has been partially harvested for its merchantable timber; the remainder is expected to be cut over in the next two years. The remoteness of the site limits its current uses to logging and some recreational uses such as hiking, cross-country skiing and hunting. However, there is no current development of the site for recreational purposes or any other purpose other than for logging.

The area surrounding this site is primarily woodlands owned by the Province or by private landowners. There are a number of farming operations and private residences along Route 126 and Indian Mountain Road. The farms and residences along Route 126 would have a buffer of 1.8 km of woodland between them and the site. The operation would not be visible from Route 126. The closest residences on Indian Mountain Road are 1.6 km from the site. Indian Mountain Road has a higher elevation than the site and it would be possible to view portions of the site from the Road. Some form of screening such as earth berms could be developed to restrict the view of the site from Indian Mountain Road.

The site and the general area are zoned agricultural which is compatible with the operation of a waste management facility.

The future land use alternatives for this site are somewhat different than the other two sites under consideration. The distance from the centre of Moncton and the cost to develop the site make it extremely unattractive as a commercial or industrial site. (It is 8 km from the TCH, requires an access road of 2 km, plus the development of all other services.) It currently provides habitat for wildlife and is adjacent to the Cocagne River. The land has agricultural potential in terms of suitability for production of crops, etc. but would have to be cleared. However, the present agricultural economics suggest that its agricultural potential is very small, at least for the forseeable future. Residential development during this century is not expected because of the availablity of more attractive land in the immediate area and elsewhere in the Greater Moncton area. The high cost of development (road access, services, etc.) is also a major deterrent in terms of any residential development. The most likely future use will be as woodland. As well, the site has potential for recreational activities such as cross country skiing. However, the development of the site as a waste management facility would not restrict the use of the adjoining properties for uses such as timber harvesting, agriculture, or recreation and would increase the potential for the actual site for recreation.

2.6.2.2 Land Marketability

This section summarizes the available information on the current marketability of the land in the area of the three sites under consideration.

Delong Drive and Berry Mills Road Sites

These two sites are adjacent to each other and are similar with respect to current and future land uses. The land bordered by Berry Mills Road, the Industrial Park, and Delong Drive is generally privately owned and most is undeveloped. What development there is in this area is along the Berry Mills Road. The two sites do not have access to electrical, telephone, water or sewage services. The Berry Mills site has no road frontage while the Delong Drive site has 890 m of road frontage on the gravel section of Delong Drive. The Delong Drive site, due to its road frontage would be more attractive for industrial or commercial development.

The assessed use of the land in the area was examined. Most of the land is classified as timber land. The market value per hectare for any particular property will depend on many factors such as proposed use, timber value, road frontage, size, dimensions, and location.

Route 126 Site

The land considered for the waste management facility, is part of a large block of Crown land and is not assessed by the Government. Private land in the area is generally assessed as timber land. The existing market value of the land, if it were available for sale, would be primarily determined by its value as a woodlot or for development as agricultural land. The potential for commercial, industrial, or residential purposes is minimal at this time. Its market value would be considerably lower than the other two sites.

If this site were chosen, as it is currently Crown Land, the transfer of the required land would be subject to a review process to ascertain if the proposed transfer would be in the best public interest. The transfer would ultimately require the Lieutenant Governor in Council's approval.

2.6.3 INFRASTRUCTURE AND SERVICES

2.6.3.1 Municipal

The Delong Drive Site falls under the jurisdiction of the City of Moncton.

For the Delong Drive Site, water services would have to be developed on-site. A City of Moncton sanitary main is located on English Drive approximately 2 km from the site.

As for the Berry Mills Road Site, water services would also have to be developed on-site. A City of Moncton sanitary main is located at the corner of Edinburgh Drive and Berry Mills Road 4 km from the site.

For the Route 126 Site, there are no municipal services located nearby. Water and sanitary sewer services would have to be developed on-site.

2.6.3.2 Rail

The Delong Drive Site is bordered to the south by the CNR Humpyard and to the north by a CNR line. It is possible that CN would consolidate all its activities in the Moncton area at the Gordon Yard and may need to expand its working area.

The Berry Mills Road Site is bordered to the north by a CNR line.

There are no rail lines in the vicinity of the Route 126 Site.

2.6.3.3 Power Line

For the Delong Drive Site, power is available at the Humpyard Scales which is at a distance of 1.8 km from the proposed access road.

If the waste management facility is placed on the Berry Mills Road Site, power can be obtained from transmission lines located approximately 1.3 km east of the site. In total, a distance of 2.0 km will have to be relayed.

For the Route 126 Site, power for the facility can be obtained from transmission lines located on Route 126 at the intersection of Melville Road and Route 126, a distance of over 2.0 km.

2.6.3.4 Highway System

The Delong Drive Site would have one of two possible access roads to the facility. The existing access to the Delong Drive Site is via Delong Drive (see Exhibit 2-1). Delong Drive connects to Edinburgh Drive approximately 2.7 km to the east of the site and to the Salisbury Road (Route 106) approximately 3.9 km to the west. Edinburgh Drive would be the primary entrance for the facility if access by Delong Drive is chosen. Therefore, traffic coming from the western section of the Region could access the site via Salisbury Road or Berry Mills Road to get to Edinburgh Drive. The eastern section of the Region could access the site via the main arteries in the Greater Moncton Area (in particular, Wheeler Boulevard, St. George Boulevard, and the Berry Mills Road) to get to Edinburgh Drive. Another possible access to this site is to the north directly onto the Berry Mills Road approximately 2.2 km west of Edinburgh Drive.

The Berry Mills Road Site would have one of two possible access roads to the facility. One possible access would be on-site access road (of approximately 800 m length) from the Berry Mills Road. Once on Berry Mills Road, the traffic would be linked to all major thoroughfares of the Region (Wheeler Boulevard and Trans Canada Highway). The other possible access would be made from Delong Drive and would be situated approximately 3.7 km west of Edinburgh Drive.

The Route 126 Site would be accessed from Route 126 at an old road no longer kept up by the N.B.D.O.T. called the Melville Road (see Exhibit 2-1). Melville Road is an old logging road which connects to Route 126 approximately 8 km from the Trans Canada Highway/Mountain Road intersection.

2.7 Transportation

This section examines the site specific aspects of the project pertaining to site access and the transportation of solid waste.

An estimate of the truck and other vehicle traffic has been made along with the distribution of traffic to the alternative routes available. The estimates on waste generation have been employed to project the commercial truck traffic. The other traffic (mostly cars and small trucks hauling the occasionl load of waste) is expected to equal 50 percent of the number of commercial haulers. In addition, the traffic analysis includes additional traffic allowance for employees, visitors and other related traffic. The overall result is that the total maximum traffic generation is estimated to be twice the commercial truck traffic. These potential increases in traffic were compared to the existing traffic levels to identify any potential traffic impacts.

The distribution of the additional traffic as provided in Tables 2-26 through 2-28 is the maximum estimates for each route. In some cases, there are more than one possible route to transport waste to the site. Therefore, where there is more than one logical route, the forecasted additional traffic is allocated to each possible route alternative. For this reason, the distribution of traffic among route sections may appear to be greater than the total estimated traffic.

2.7.1 CURRENT USAGE AND CONDITION OF ROADS LEADING TO THE SITE

Delong Drive Site

The current access for this site is on Delong Drive opposite the CNR Humpyard. The site access would be 2.7 km west of the intersection of Delong Drive with Edinburgh Drive and 3.9 km east of the intersection of Delong Drive with Salisbury Road (Route 106). Delong Drive, with the exception of the section between Edinburgh Drive and the access to the CNR Humpyard (one kilometre) is a low standard gravel road which becomes rutted and very muddy in the spring. The truck and other vehicle traffic to and from the site would necessitate up-grading and paving of this road, at least from the humpyard to the site. An alternative to the above access is to construct to the north from the Berry Mills Road. The access road would cross the CNR rail line and Jonathan Creek.

Berry Mills Road Site

The access for this site could be from Berry Mills Road. This would require the construction of an 800 metre road from Berry Mills Road. The access road, which would intersect Berry Mills Road at a designated access point, would cross a CNR rail line and Jonathan Creek. The projected traffic levels would warrant crossing lights at the rail crossing. A culvert would be required at Jonathan Creek.

An alternative to the above site access plan would be to construct a 2.1 km access road from Delong Drive. In this case, the access road would not cross the rail line nor Jonathan Creek. However, it would be a much longer road and would intersect the N.B.E.P.C. easement.

Route 126 Site

The access to the site would be from Route 126. An old logging road, Melville Road, located approximately six km north of the Trans-Canada Highway would be upgraded. Starting at Route 126, 1.8 km of the Melville Road will be upgraded (east of Route 126) to reach the site.

2.7.2 TRAFFIC

Delong Drive Site

Table 2-26 presents the current traffic on the various transportation routes that would be used to reach this site. Also included in the table is the maximum additional traffic generated by the operation of the proposed waste management facility. A comparison of the current traffic and the additional traffic suggests that the impact will be insignificant. Furthermore, the total projected traffic would be within the design capacity of the relevant road network.

A minor traffic congestion problem exists at the intersection of St. George Street and Edinburg Drive. The City of Moncton is in the process of installing traffic signals at this intersection to address the problem. The only other possible deficiency or concern with respect to vehicle traffic would be the need to upgrade the gravel road section of Delong Drive as mentioned previously.

The enforcement of waste transportation regulations will be required to minimize roadside littering. This will be particularly important for vehicles passing through the industrial park.

If access is constructed to the Berry Mills Road, the same situations as described below for the Berry Mills Road Site will apply.

Berry Mills Road Site

Table 2-27 presents the results of the traffic impact analysis based on a Berry Mills access. Again, no significant traffic impacts are expected. The major routes that would experience increased traffic are Berry Mills Road, and Wheeler Boulevard. The increase in traffic for these road sections is considered insignificant.

TABLE 2-26

Daily Traffic Generated on Selected Route Sections by Delong Drive Waste Management Operation

Route Section	Estimated Average Daily Traffic (1989)*	Maximum Additional Trucks	Other Traffic	Total Additional Traffic
North Wheeler Boulevard	11,940	88	88	176
North end of Edinburgh Drive	10,109	88	88	176
Riverview-Moncton Causeway	21,900	24	24	48
Baig Boulevard	na	24	24	48
South end of Edinburgh Drive	8,553	24	24	48
East end of Delong Drive**	na	104	104	208
West end of Delong Drive**	na	8	8	16

* Source: Traffic Flow Map (1989), New Brunswick Department of Transportation.

** Private Road: AADT estimates not available

TABLE 2-27

Daily Traffic Generated on Selected Route Sections
by Berry Mills Waste Management Operation

Route Section	Estimated Average Daily Traffic (1989)*	Maximum Additional Trucks	Other Traffic	Total Additional Traffic
Trans Canada Highway west of Moncton	8,230	28	28	56
Trans Canada Highway east of Moncton	11,000	20	20	40
Berry Mills Road west of site	4,100	28	28	56
Berry Mills road east of site	4,100	96	96	192
Riverview-Moncton Causeway	21,900	24	24	48
Wheeler Boulevard north of Berry Mills Road Interchange	11,940	44	44	88
Wheeler Boulevard south of Berry Mills Road Interchange	14,880	52	52	104

*Source: Traffic Flow Map (1989), New Brunswick Department of Transportation

The maximum additional traffic on Berry Mills Road is 112 trucks and 112 other vehicles per day. This volume of traffic is not expected to have any impact on the capacity of Berry Mills Road.

However, almost half of these daily trips involve left turns off Berry Mills Road to the site. Since the average operating speed on Berry Mills Road is 100 km/hour, the left-turns could pose a safety hazard. For safety reasons and also to reduce delays to traffic on Berry Mills Road, it may be necessary to widen a 100 m section of Berry Mills Road approaching the site, to permit a separate left-turn lane. It may also be necessary to install a deceleration lane for traffic approaching from the West. As well, although Berry Mills Road does not present any significant safety problems in terms of sharp curves, blind knolls, or steep grades, the access road to the site from Berry Mills Road crosses the CN rail line, making it necessary for traffic control devices to be installed on the access road.

If access is constructed to Delong Drive, the same situation described previously for the Delong Drive Site will apply.

Route 126 Site

Table 2-28 presents the results of the traffic impact analysis for this site. The most significant traffic increase would occur on Route 126 from the site access to Wheeler Blvd. The maximum daily increase in traffic on this road section would be 112 trucks and up to 112 other vehicles. This incremental traffic is insignificant in comparison to the current traffic levels. However, there are already some safety concerns and traffic congestion on Route 126 between the TCH and the intersection of Front Mountain Road.

The Magnetic Hill Tourism Centre results in severe traffic congestion during peak tourism season. The commercial development combined with the tourism information centre attract large numbers of tourists entering and exiting Route 126. This situation creates both a traffic congestion and a traffic safety concern.

Other traffic concerns related to this site include: the requirement to pass directly through a school zone (Magnetic Hill School); the vertical alignment (steeper grades) of Route 126 result in traffic delays and safety concerns particularly when the road is slippery; and a small amount of additional truck traffic is expected on Indian Mountain Road which is primarily a rural residential road not suited for ongoing truck traffic.

2.7.3 SAFETY

The previous section has identified the additional traffic that would be generated by the various proposed sites. Particular traffic congestion and safety concerns were also identified. The overall impact on traffic volumes is not expected to be significant for any of the sites. This conclusion is reinforced by comparing the current traffic accident rates with the impact of the additional traffic on these rates.

TABLE 2-28

Daily Traffic Generated on Selected Route Sections by Route 126 Waste Management Operation

Route Section	Estimated Average Daily Traffic (1989)	Maximum Additional Trucks	Other Traffic	Total Additional Traffic
North Wheeler Boulevard	11,940	28	28	56
South Wheeler Boulevard	14,880	52	52	104
Riverview-Moncton Causeway	21,900	24	24	48
Mountain Road between Wheeler Boulevard and Trans Canada Highway	18,400	112	112	224
Mountain Road, north of Trans Canada Highway	6,500	112	112	224
Trans Canada Highway, West of Route 126	8,230	26	26	52
Trans Canada Highway, East of Route 126	11,000	22	22	44

Table 2-29 provides the current accident rate (number of accidents per million vehicle kilometres) for the critical sections of the transportation routes that would be used for the three different sites. This rate is contrasted with the rates that would be expected if the various alternative sites are developed as the waste management site. The accident rate impact is determined by examining the current accident rate and traffic volumes and estimating the impact of the maximum additional traffic that would be generated under the three alternatives.

TABLE 2-29

Impact on Traffic Accident Rate

Route Section	1990 Accident Rate*	1990 Accident Count	Berry Mills Site*	Delong Drive Site*	Route 126 Site*
Berry Mills Road - TCh to Wheeler Blvd.	1.871	21	1.984	1.871	1.871
Route 126 - TCH to Melville Road	0.702	4	0.702	0.702	0.727
Mountain Rd.- Wheeler to Main St.	8.446	329	8.455	8.455	8.472
Wheeler Blvd. - Berry Mills to Main St.	0.603	19	0.607	0.607	0.605
Causeway	2.729	24	2.735	2.735	2.735
Main Street	9.912	234	9.925	9.925	9.925
Edinburg Dr.	1.265	14	1.265	1.296	1.321

* Figures presented are the current accident rates (column 1) and the expected accident rates (columns 3, 4 and 5) for each potential site. The accident rates are expressed in accidents per million vehicle kilometres.

Note: No traffic or accident rate information is available for Delong Drive.

The current and projected accident rates exhibit considerable variation (0.237 to 9.912 accidents per million vehicle kilometres). The major traffic routes for Moncton such as Mountain Road, Main Street and St. George Street exhibit the higher accident rates, primarily due to their higher traffic volumes. However, the impacts in terms of increased accident rates for these route sections are expected to be extremely small (less than 1%). The other lower volume routes have much lower accident rates and thus the increase in traffic will have a greater impact in the accident rate. However, the overall increase in accidents would be expected to below (one or fewer additional accidents per year).

3.0 DESCRIPTION OF PROJECT ACTIVITIES

3.1 Wastes

3.1.1 MUNICIPAL WASTE GENERATION AND COMPOSITION

In 1989, it was estimated that a total of approximately 86,000 tonnes of solid waste was generated in the Westmorland/Albert Region. In a previous report entitled "Waste Audit" prepared by ACI Limited, the following generation rates, also used in other areas of the Atlantic Provinces, were used to calculate this amount:

Urban Centres	*2.1 kg/person/day or* *5.5 kg/household/day*
Rural Areas	*2.2 kg/household/day*

Also using these figures, it was determined that on average each household currently generates approximately 0.8 tonnes of solid waste per year.

In the Westmorland/Albert Region, the composition of solid waste is composed of 9 main categories as shown in Exhibit 3-1. These waste types are found in the residential, commercial, industrial, institutional, and construction/demolition waste streams. The approximate waste generation by source expressed as a percentage is as follows:

Residential (household)	44%
Commercial	46%
Industrial	5%
Institutional	2%
Construction/Demolition	1%
Other	2%

However, the proportion of residential garbage in the solid waste stream as opposed to other sources varies from one part of the Region to another. In the more urban centres, such as Moncton for example, where commercial and industrial operations are extensive, more of the material will come from these sources. In contrast, residential areas and rural communities generate solid waste with a higher portion of household refuse.

Over the next 25 years, the population of the Region is expected to increase by about 35% to 190,000 people (as shown in Table 2-24). Unless steps are taken to reduce the amount of waste being generated, the total amount of municipal solid waste requiring disposal is expected to increase by at least the same proportion to 115,000 tonnes per year (see Table 3-1).

Exhibit 3-1

Composition of municipal solid waste for the Atlantic Region

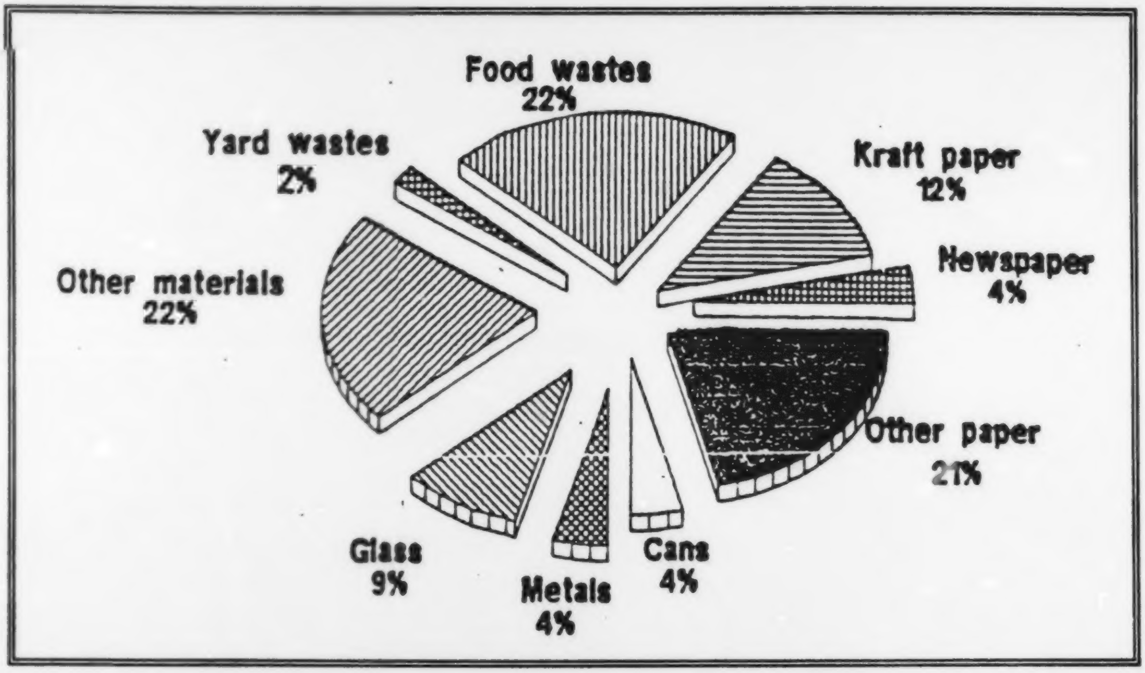


TABLE 3-1

Predicted Waste Tonnage For Westmorland/Albert Counties

COUNTY	PREDICTED TONNES OF WASTE GENERATED*					
	1989	1994	1999	2004	2009	2014
Westmorland	69 800	73 800	78 000	82 700	87 700	92 900
Albert	16 200	17 300	18 500	19 600	21 000	22 300
Totals	86 000	91 100	96 500	102 300	108 700	115 200

* All waste streams

The WASWPC has, however, taken steps to ensure a decrease in the solid waste stream in the future. The following goals have been set: 30% of the total waste generated in the Region will be diverted from the landfill by the year 1995, and 50% will be diverted by the year 2000. Waste generation reduction and possible diversion methods such as recycling activities, composting, and improvements in packaging will be necessary to meet these targets.

3.1.2 COLLECTION AND DELIVERY OF MUNICIPAL WASTES

When the proposed waste management facility is in operation, it is understood that the majority of the Region will have a local organized collection and transportation system developed. Urban transfer systems will not be necessary or economical because of the proximity of the major urban areas to the disposal facility. Based on previous transportation analyses, there will be no requirement for transfer stations in the more rural areas if a region wide collection service is instituted.

At present, 33,800 (72%) of the 47,000 households are served by a residential curbside collection service. This service is provided through 9 of 12 municipalities and 13 of 34 local service districts. The remainder of the residential (domestic) wastes is either hauled to a local disposal site by the generator or they hire a commercial collection contractor on a user-pay basis. Typical collection vehicles used to provide residential collection range from small pick-up trucks with built-up boxes to 19 m^3 compaction vehicles.

Commercial collection contractors presently provide services to commercial, industrial and institutional waste generators on an individual user-pay basis. Typical collection vehicles used by the contractors range from one-ton trucks to sophisticated container type vehicles. The larger vehicles are either front-end loading (FEL) that pick up the contents of containers ranging from 2-8 cubic yards (CY) with several of these consolidated in one vehicle to make a full load or rear loaders that provide roll-on, roll-off containers in the 15-50 CY capacity. Several models utilize compaction systems to increase the density of the waste to be transported for disposal. Many generators also use their own vehicles and employees to transport wastes.

Because of the greater haul distance to the proposed waste management facility as compared to the existing dumps, greater efficiency will be required in the pick up and delivery systems presently serving most of the smaller communities and outlying districts. The Solid Waste Commission will organize a collection and transportation system to serve all residents in the existing service. Transportation (line haul) costs will be equalized throughout the region. With the regional collection system and equalized transportation costs both environmental and economic impacts will be minimized. Special collections for yard waste, bulky materials and household hazardous wastes will be scheduled as required.

3.1.3 OTHER WASTES

The proposed Westmorland/Albert Integrated Waste Management Facility, which will have containment, collection and treatment of leachate from the landfill, will be capable of safely handling a variety of non-hazardous wastes. All such materials must be of a consistency to be landfillable and would only be accepted with the approval of the WASWPC.

Wastes considered to be acceptable or landfillable are those generated in the typical waste stream. These include household refuse, institutional wastes (e.g. food wastes), and some commercial wastes. Wastes that will not be accepted for landfilling include biomedical wastes, chemical wastes, hazardous wastes, petroleum wastes, fish wastes and meat processing wastes.

Special areas will have to be developed at the site to safely handle other wastes that are not easily landfilled. These may include septic and sludge wastes, agricultural wastes, etc.

In particular, sludge wastes from the Greater Moncton Sewage Commission plant accepted at the proposed facility will be brought to a special area of the facility. The GMSC plant will contain sludge dewatering and conditioning facilities. Its sludge will have a solids content in excess of 25 percent and be lime stabilized by adding lime and mixing to generate a pH in excess of 12 for two hours. This will reduce the possibility of odours and provide for easier handling. A further conditioning on a covered concrete pad will also be necessary. Mixing equipment would be provided and it is expected that further drying of the sludge would occur. Sludge dewatered and conditioned in this matter would be suitable for use as daily cover at the landfill and therefore would not be classed as a waste for disposal.

Besides having special areas to handle wastes that are not easily landfillable, it is also anticipated that areas will be provided for placement of construction and demolition wastes that do not need to be placed in a secure landfill. These inert materials would not require the same design requirements as the sanitary landfill. Areas for bulk recyclables, such as scrap metals and tires, will also be necessary.

3.2 Site Layout and Related Infrastructure

3.2.1 DEVELOPMENT OF THE LANDFILL AREA

Development of a landfill area within an integrated waste management facility is dependent on the physical and geographic characteristics of the area. This section details a generic site layout for the sanitary landfill with emphasis on how the site can be situated on and operated for any one of the previously determined sites.

A typical layout for a sanitary landfill includes:

- access road (on-site),
- borrow pits,
- central zone (buildings, salvage area, weigh scales, etc.),
- constrained areas (on-site),
- environmental monitoring stations,
- leachate recovery/treatment facility/secondary containment,
- ponds (fire & sedimentation),
- property boundaries and setbacks,
- visual buffers, and
- working cells.

Drawings 1-1 to 1-3 (Appendix G) show concept layouts for each of the sites.

The site components mentioned above will possess the following minimum design criteria.

Access Road

The on-site access road will be durable enough to last the site's lifespan. This requires that the main on-site road be constructed of an asphaltic concrete and individual cell perimeter roads be of at least a gravel base. Within the working cell itself, the roads may be constructed of a well draining shale material.

Borrow Pits

Material for the daily operation will be obtained either from the on-site borrow pit or from a borrow pit off-site. Whatever is the most economical for a particular site will be the preferred choice. Material excavated will be in the CL soil classification and will be of a consistency that the daily operation can be covered with a minimum six inches of soil.

Central Zone

The central zone can also be referred to as the control center for the operation of an integrated waste management facility. With respect to the landfill operation, several key structures will be present: administration, maintenance, recycling, and weigh scale.

Areas pertaining to the central zone will also be set aside to receive various salvaged materials such as: asphalt, concrete, timber, and metals; storage of surplus pipe, manholes, etc. used for the landfill operation; and a secure area to park landfill equipment not in use.

Constrained Areas

Within a landfill site there are usually areas that for one reason or another cannot be used as a working area to dispose of the regions waste nor can they be used for other landfill functions as noted above.

These areas can consist of low wet spots with poor drainage, buffers that have been agreed to with the regulatory authority, outcrops of bedrock, etc. These areas will be clearly identified in the design process and avoided during and after the site is in operation. Usually, it is good practice to mark these areas with permanent markers so that over the life of the operation any site operator is visually aware of the constrained areas.

A typical example is shown on Drawing 1-1, the Delong Drive Site, where the western portion of the site has a distinct low area which has been constrained out by using established setback criteria.

Other examples of this type of constraint can be seen in Drawing 1-2, Berry Mills Road Site, where portions of the site in the northeast corner and the southwest corner have been constrained out due to wet areas; or the Route 126 Site, Drawing 1-3, where the only portion of this site effected is the southeast corner.

The constraint lines for the three sites being considered will be based on the following setbacks:

adjacent property	100 m
existing highways	150 m
water bodies	300 m

Environmental Monitoring Stations

WATER

Environmental monitoring stations for surficial water and groundwater will be established both on and off the site.

The surficial water monitoring will be done using the existing drainage basin flow pattern and establishing specific sample collection stations upstream and downstream from the site. These sampling stations will be clearly identified with permanent markers so that a consistent sampling program can be done over a period of time. Each sampling station will be coordinated to the N.B. survey monument markers for horizontal and vertical control.

Groundwater monitoring is normally accomplished through newly placed piezometers or wells and existing local wells. The piezometers or wells are located on and off the site based on the the geological and hydrogeological assessment of the site. They will also be coordinated for horizontal and vertical control. The piezometers will normally be placed in clusters or nests to facilitate the varying depths of the determined aquifers. Local wells, which have been identified as having sufficient well data, could also be included in the groundwater monitoring program if sufficiently close.

GASES

Environmental monitoring stations for landfill gases will be based on the type of system developed, i.e. passive or active.

In general, a passive system is vented direct to the atmosphere and a routine inspection of each of the vents using an explosimeter could determine if the vents are functioning. On the other hand, an active system collects the landfill gases by a series of pipes and blowers and transfers the gases to a single point source from where it could be utilized if the quality and quantity is sufficient or at a minimum flared (waste burned). These type of systems are normally under pressure and are monitored on a continuous basis to ensure that there are no leaks in the system.

As methane gas is colourless and odourless, a proper gas sample collection test will be necessary in order to determine the presence of methane. A simple and effective method used at some landfills, to determine if there is a migration of landfill gas, is to plant vegetation that is susceptible to gas poisoning. This vegetation is usually planted at the perimeter of the site to ensure that gases are not migrating off the site.

At the present time, other forms of air monitoring are not normally carried out at landfills.

Leachate Recovery/Treatment Facility

The leachate recovery system will be located within a working cell in such a manner that all the leachate generated within the cell is collected and transferred where practical by gravity flow to a single low point on the site. At this low point, the leachate will be collected and treated in an on-site treatment facility, and then trucked or pumped off-site to a publicly owned wastewater treatment facility.

Ponds

Typically, a landfill is normally located where either fire protection services are minimal, or the distance/time to be travelled by the fire trucks to obtain large quantities of water increases the chances of an on-site fire spreading out of control.

To protect against this, on-site fire ponds will be established at the landfill. The ponds will be constructed to hold sufficient quantities of water to be used by the fire fighters in the advent of a major fire.

These ponds could be developed in such a manner as to provide a dual function: fire protection and sedimentation control. During design of the system, settling tests would be carried out to determine settling time and appropriate sizes for the ponds.

Sedimentation control is requred at a landfill due to the development of large areas at one time (i.e. approximately 5 hectares per phase for the proposed landfill) that exposes soil to the elements. It is normal practice at a landfill site to clear, grub, excavate, and develop a five year working cell to maximize an effective operational activity.

Property Boundaries and Setbacks

From an adjacent property, the landfill dimension setback according to established guidelines is a minimum 100 meters. This allows a buffer zone which, for the three proposed sites, consists of trees and shrubs. This natural buffer protects the day-to-day operation from visually impacting on the public.

Other setbacks are typically from nearby residences, industries,and institutions; watercourses; sensitive environmental areas; etc. For the three proposed sites all the established setbacks have been considered and exceed the prescribed guidelines of 500 m from residences, 300 m from watercourses, etc.

Visual Buffers

Visual buffers at each of the three proposed sites for the most part are of a natural tree and shrub variety. If for some reason an area becomes exposed to public view, an earth berm will be developed of sufficient height to minimize the visual impact. Earth berms afford a visual buffer that could also act as a long term storage pile for topsoil until it is required or for interim stockpiling of daily cover.

Working Cells

The working cells proposed for the landfill will be approximately 6 hectares in area with a working depth of 15 meters. This cell size will provide approximately five years of operation per phase. A liner system for leachate containment will be installed on the bottom. Above the liner, a leachate recovery system will be installed in a drainage layer. This layer will be protected with a geotextile fabric to protect from soil fines clogging the recovery system.

The cells will be constructed in a manner to maintain at least 1.5 m of till material between the liner and bedrock. Due to the varying thickness of existing tills on the sites and the natural ground slope, cells could be constructed totally above existing ground surface in some parts of the sites while excavation of up to 5 m may occur elsewhere.

On a daily basis, solid waste will be placed within an area of the working cell and will be covered with a nominal 150 mm of soil. Assuming an average daily total of waste entering the facility to be 340 tonnes (5 day per week basis), the daily cell will have a total volume of 480 m^3 (including daily cover material).

Once the capacity of each cell is reached, the final cap of approximately 1 meter in depth will be placed consisting of soil and geotextile materials to allow a vegetative cover to be developed and prevent infiltration.

Annually, a portion of the working cell will be completed to minimize sediment and erosion impacts on the site, reduce leachate generation, and to provide as early as possible the desired site after use.

3.2.2 DEVELOPMENT OF OTHER COMPONENTS

The development of other components within the integrated waste management facility will be dependent on several key factors such as volumes of other wastes, appropriate technologies, and markets.

An integral part of the solid waste commission's role will be the reduction in waste that is received at the facility. A program is being developed to advise the public on ways that can be used to reduce the amount of waste set out for collection or delivered to the waste management facility. This could include backyard composting, avoidance of environmentally unsound packaging, etc.

Although the focus is on material that is considered solid waste and landfillable, it is necessary to discuss solid wastes that can either be diverted from the landfill for reuse or recycling, to save valuable space, or should not be allowed to be disposed of within the landfill due to the negative impacts they may cause. Some of these wastes include asphalt, batteries, concrete, leaf and yard wastes, metals, glass, paper products, plastics, timber, etc. Currently, some recycling and/or reuse of the products mentioned above is being done on a commercial basis where it has been considered viable, otherwise these solid wastes are being landfilled.

To ensure that these materials are removed from the municipal solid waste stream, alternative methods of utilization/disposal will be found. Some methods presently being employed elsewhere are listed below:

- providing collection service for recyclables and material recovery facilities
- composting organics
- crushing/grinding and grading construction materials
- shredding and utilizing as insulation materials
- placing landfill bans on materials that can be recycled or composted.

Composting of organics is one method which will become a component of the proposed integrated waste management facility. Composting is a form of material recovery, in that compostable materials are separated and retrieved, or recovered and diverted from landfill. Almost all food scraps (except meat and oil, which will attract animals), as well as yard wastes (including leaves, branches, brush, and shrub and grass clippings) can be composted. Organic matter in the form of household and yard waste generally accounts for 25% to 30% of municipal solid waste. This translates into approximately 22 000 to 26 000 tonnes which could potentially be composted each year at the proposed integrated waste management facility. The equipment and area required for such an operation are dependant on the technology chosen. The area required for the composting operation could range from five to ten acres.

In order to attain the diversion goals set by the Westmorland/Albert Solid Waste Provisional Committee, recycling will also become a component of the proposed integrated waste management facility, provided markets for recycled materials are available. The term recycling is commonly applied to the processing of materials into new products that may or may not resemble the original material. Materials which can be recycled include paper, newspaper, corrugated cardboard, aluminum cans, steel cans, glass, and plastics, which account for approximately 55% of the municipal solid waste stream in the Region. While there are many variations possible, three basic recycling approaches have evolved: source separation of dry recyclables, wet/dry systems, and mixed solid waste processing systems. Regardless of the approach chosen, recyclable materials arriving at the facility would be sorted, either manually or mechanically, in an enclosed building and would then be transported to an end user.

To meet the targets for diversion from landfill adopted by the Solid Waste Committee a major recycling and composting operation will be necessary. All wastes will be processed at the central facility following a wet/dry or co-mingled collection. It is estimated that the recycling component will divert 25 to 35 percent of the waste, and the composting component 25 to 40 percent of the waste. The actual split will depend on the available markets and the technology used.

The facility would include the dry materials area consisting of a totally enclosed building with a receiving area and a processing area housing a combined hand and mechanical sorting. The wet side or composting section would consist of a separate building with wet material receiving and a fully enclosed reactor cell building, an outside curing and storage area and a biofilter or other type of system for odour control. A drainage collection system would be installed to direct any contaminated water to the leachate treatment plant. Organic kitchen wastes from residential, commercial, institutional operations and yard wastes would be processed in the "wet" operation.

Further to the above, new proven technologies will be continually researched by the Commission to determine their applicability to the regional solid waste management program. Selected technologies could be incorporated into the facility through incentive programs either on a community basis or as new commercial ventures within the integrated solid waste management facility. The Commission could assist entrepeneurs in seeking out funding partners.

In conjunction with establishing new proven technologies, assistance from the Commission could be provided to local research projects that are attempting to develop new methods and markets for the utilization of the Region's municipal solid waste. This assistance could provide new local industries which in turn could market the new methods to other regions and or provinces.

3.3 Landfill Operation

3.3.1 GENERAL

Initially, most of the municipal solid waste generated within the Westmorland/Albert region will be disposed of in the sanitary landfill.

A sanitary landfill is a controlled access facility where solid waste is received and disposed of under continuous supervision. The solid waste is spread in thin layers, compacted, shaped into a cell, and covered with soil every operating day.

Proper design requires that the waste be contained and that effluent (leachate or runoff) be collected and treated to established criteria before discharge to the environment. An integral component of a sanitary landfill is the environmental monitoring and protection systems which are installed prior to the site going into operation. On-going monitoring of these systems ensures no negative environmental impacts result from the site operation.

The site will be operated by a staff of ten, consisting of: a site operations manager, a bookkeeper/secretary, three equipment operators, a scale operator, three attendants, and an environmental technologist.

The site operation manager and bookkeeper/secretary will oversee the operations of the site to ensure the facility is run efficiently and economically.

The environmental technologist will be responsible for the environmental monitoring program along with all other environmental control.

The scale operator (weighmaster) and one attendant will be responsible for the control of waste entering the site. The weighmaster will run the scales, inspect the waste, and direct commercial haulers to the operating cell attendant. The scale attendant will be responsible for collection of entrance fees which are not handled by third party billing, and control of the private haulers.

The other attendants will be responsible for directing traffic to the cell, control of appearance of the site, and security.

The equipment operators will be responsible for operation and routine maintenance of the equipment used for the landfill operation.

Other positions related to management and the recycling and composting operations will be created as necessary. It is anticipated that up to 40 people could work at the site during full scale operation.

The site will be open from 8:30 am to 4:30 pm, Monday to Friday; and from 8:30 am to 12:00 pm on Saturdays. The site will be open to the general public.

3.3.2 CONTROL OF WASTE TYPES

Control of waste types is an essential component of every sanitary landfill. It allows the administration personnel a way of assessing the efficiency of the operation and facilitates present and future planning. To properly control the waste entering the facility, the quantity, type, and location where it has been disposed of within the landfill must be known.

The landfill will be set up on a grid system with cross sections of the entire site. This will serve as a basis for all future computations and allows the waste to be geographically located as to age and possibly type.

Signage at the entrance to the site will state specifically what wastes are acceptable and can be safely disposed of at the sanitary landfill. Control of acceptable solid wastes will be primarily the responsibility of the site's scale operator and the equipment operators. An extensive public information program will be implemented to identify to the public wastes to be deposited at the landfill or other more secure areas.

All commercial haulers will have their waste weighed and be charged by the tonne. They then will be directed by the attendants to the active cell where they will discharge their load under direction from the cell attendant. Haulers with small quantities will be charged an entrance fee to dispose of their waste in a transfer station located near the entrance. All waste entering the site will be inspected by the attendants.

Wastes which cannot be disposed of under normal landfilling procedures will not be allowed to enter the site unless prior provisions have been made.

Waste entering the site will be geographically located and recorded on site drawings by the cell attendant. Cross sections will be completed annually and compared with other site information to determine compaction densities to enable accurate projections of expected landfill site life.

3.3.3 CONTROL OF WASTE DELIVERY

The site will have a fence constructed around the perimeter to prevent animals from entering the facility and to discourage trespassing. Appropriate signs will be provided along the fence to describe the nature of the facility and warn against trespassing. A collector fence will be erected around the perimeter of the active working area to catch windblown litter.

At the facility entrance, a sign will be erected to identify the facility and the days and hours of operation. Other functional signs will be erected at the active working face, leachate collection and sedimentation ponds, and recycle and salvage areas. Speed limit and direction signs will be erected.

The site's weighmaster will be located at the entrance to the site in the scale house. The weighscale house will have direct communication links to all areas and buildings on-site.

The site user upon arriving will report to the scalehouse. The weighmaster will collect all the pertinent information including the types and quantities of wastes received from the commercial haulers and enter the information into a computer system linked directly to the administration building. Billing of commercial haulers will be done on a tonne received basis and by third party billing. Commercial site users will then be directed by the weighmaster where to unload their vehicle (working face, recycle

building, salvage area). Site attendants working in these various areas will be responsible to supervise the unloading of the vehicles. After the solid waste is unloaded site personnel will then dispose of it in the appropriate manner.

For private haulers having small volumes of solid wastes, a drop-off bin will be provided (transfer station). This transfer station will be located just inside the site fence. This drop-off bin system alleviates a potentially dangerous situation occuring between commercial vehicles and private haulers attempting to unload their vehicles at the active working face.

3.3.4 DISPOSAL ACTIVITIES

Disposal activities are the direct responsibility of the site's operational manager who determines on a daily basis the method and location of disposing of the solid wastes received. Some factors which might affect his decision are: present cell height, weather, expected volumes and types of solid wastes, season, wind direction, equipment and personnel availability, etc.

The site manager's support personnel including foremen, site attendants, equipment operators, and labourers make up the component who control the disposal activities on a daily basis.

At the working face, site attendants control vehicle movements and the unloading procedures. Equipment operators then use bulldozers and compaction equipment to spread the waste in thin layers and to reduce the size of the waste to the least practical volume by compaction. Subsequent loads are received and handled in a similiar manner until a daily cell is created. Once the cell is shaped, approximately 150 mm of cover material is applied over the waste on a daily basis.

At the recycle building site attendants control vehicle movements and provide specific drop-off areas for the materials (paper, glass, plastics, etc.) to be received either within the building or in outside stockpiles. Labourers then sort the material and package it for shipment to the recycle markets.

The salvage areas are normally controlled by one of the cell attendants. The site attendants control vehicle movements and placment of materials (asphalt, concrete, metals, etc.) into the appropriate stockpiles. These materials are normally stored outside and are usually transported on a truck load lot basis to their respective markets.

3.3.5 CONTROL OF SURFACE RUNOFF

Control of surface runoff for the overall site will utilize open vegetated diversion ditches and culverts when crossing site access

roads. All surface water from cleared areas will be directed to the sedimentation ponds prior to discharge to the environment. Culvert pipe will also be used where deep cuts may create a safety concern. Surface runoff from the active landfill area will be directed to the leachate collection ponds.

3.3.5.1 Soil Erosion

Soil erosion will be controlled primarily by maintaining existing vegetative growth for as long as practical. No area will be developed until it is absolutely required.

At the time an area is opened for development of a working cell by clearing, grubbing, and excavation, the diversion drainage ditches will also be constructed to divert surface runoff away from the disturbed areas. Areas within the site and stockpiles of excavated materials having a high potential for erosion will be properly sloped to minimize soil erosion.

Completed working cells will be shaped, capped, and a vegetative cover developed annually to reduce erosion. If settlement or soil erosion occurs locally prior to establishment of a vegetative cover, then the affected area will be reshaped and seeded out. Diversion ditches will be maintained regularly.

3.3.5.2 Sediment Reduction

Similar to the above, sediment reduction will be controlled and maintained by not opening areas for solid waste disposal until they are necessary, constructing sediment traps in problem areas, proper sloping of stockpiles of borrow material and finished working cells, and developing vegetative cover on finished areas and ditches as soon as practical.

Sediment traps will be constructed from either sand bags or straw bales to minimize any potential impacts downstream.

3.3.6 CONTROL OF LEACHATE

Leachate is generated when water, mainly from precipitation, percolates through a landfill, dissolving soluble components of the refuse and flushing out any liquids present. Leachate resulting from water infiltration and waste decomposition commonly contains elevated levels of heavy metals and toxic chemicals, due to the ongoing chemical and biological reactions within the landfill.

Leachate flow and composition vary considerably from landfill to landfill because of factors such as the age of the landfill, the location of the landfill, the waste contents of the landfill, as well as landfill management practices.

As time passes by, leachate characteristics change due to the stabilization of the landfill. As a landfill site is developed, different parts of the landfill will be at different stages of stabilization. Therefore, leachate collected for treatment will likely reflect characteristics based upon a mixture of stabilization phases. The changing characteristics of landfill leachate are demonstrated in Table 3-2. Table 3-3 presents a data summary for a variety of leachate sources, which further illustrates the variability of leachate composition. In order to efficiently control the leachate produced in a landfill, working cells must be covered and "capped" as operations proceed, and collection and treatment of leachate must occur.

3.3.6.1 Effluent Standards

According to N.B.D.O.E. officials, landfills in N.B. are required to meet effluent standards for leachate where discharge is to a surface water body. The Canadian Council of Resource and Environmental Ministers (CCREM) guidelines for freshwater aquatic life must also be respected. The leachate quality before discharge must meet both Standards A and B as outlined below:

Standard A

The leachate must be ***Non-Acutely Lethal*** as per the "Acute Lethality Test Using Rainbow Trout" Report EPS 1/RM/9, July, 1990, Environment Canada

and

Standard B

The leachate must not exceed the following limits (total concentrations):

5-day BOD	40 mg/l
COD	100 mg/l
pH	6.0 - 9.5
aluminum	0.75 mg/l
iron	2 mg/l
cadmium	0.008 mg/l
chromium	0.1 mg/l
copper	0.02 mg/l
lead	0.02 mg/l
mercury	0.0008 mg/l
nickel	0.5 mg/l
zinc	0.2 mg/l
TSS	80 mg/l

TABLE 3-2

Leachate Characteristics

PARAMETER	LEACHATE FROM RECENT WASTES	LEACHATE FROM AGED WASTES
pH	6.2	7.5
COD (Chemical Oxygen Demand) (mg/l)	23800	1160
BOD (Biochemical Oxygen Demand) (mg/l)	11900	260
TOC (Total Organic Carbon) (mg/l)	8000	465
Volatile Fatty Acids (as C)	5688	5
NH_3-N (mg/l)	790	370
NO_3+-N NO_2-N (mg/l)	3	1
Phosphate (PO_4) (mg/l)	0.73	1.4
Chloride (Cl) (mg/l)	1315	2080
Sodium (Na) (mg/l)	960	1300
Magnesium (Mg) (mg/l)	252	185
Potassium (K) (mg/l)	780	590
Calcium (Ca) (mg/l)	1820	250
Manganese (Mn) (mg/l)	27	2.1
Iron (Fe) (mg/l)	540	23
Nickel (Ni) (mg/l)	0.6	0.1
Copper (Cu) (mg/l)	0.12	0.3
Zinc (Zn) (mg/l)	21.5	0.4
Lead (Pb) (mg/l)	1.4	0.14

TABLE 3-3

Range of Leachate Composition

PARAMETER	RANGE OF VALUES
COD (mg/l)	40 - 80,000
BOD (mg/l)	81 - 33,000
TOC (mg/l)	256 - 28,000
pH	3.7 - 8.5
TS (mg/l)	0 - 59,000
TDS (mg/l)	584 - 44,900
SS (mg/l)	10 - 700
Conductivity	2,810 - 16,800
Alkalinity ($CaCO_3$)	0 - 20,850
Hardness ($CaCO_3$)	0 - 22,800
Total P (mg/l)	0 - 130
Ortho P (mg/l)	6.5 - 85
NH_3-N (mg/l)	0 - 1,106
NO_3-N+NO_2-N (mg/l)	0.2 - 10.29
Ca (mg/l)	60 - 7,200
Cl (mg/l)	4.7 - 2,467
Na (mg/l)	0 - 7,700
K (mg/l)	28 - 3,770
SO_4 (mg/l)	1 - 1,558
Mn (mg/l)	0.09 - 125
Mg (mg/l)	17 - 15,600
Fe (mg/l)	0 - 2,820
Zn (mg/l)	0 - 370
Cu (mg/l)	0 - 9.9
Cd (mg/l)	0.03 - 17
Pb (mg/l)	<0.10 - 2.0

Data compiled by Chian and DeWalle
(All values except pH and Conductivity in mg/L (Conductivity in μmhos/cm)

These Standards must be met without the leachate being diluted by the surface runoff from the disposal site.

Should the leachate accidentally enter a nearby watercourse, dilution in the receiving water body must be sufficient (at least an 8 to 1 dilution factor) to achieve water quality guidelines based on the 10-year, 7-day low flow.

Where leachate can be discharged to an existing municipal collection and treatment system, the requirements for leachate effluent quality would be modified to meet local bylaws and capacity of the treatment system.

3.3.6.2 Containment and Collection

The purpose of the liner system at the landfill site is to contain the waste and prevent migration of the leachate from the site which could result in contamination of the groundwater. In addition to a liner, the leachate containment and collection system includes collection drains, piping and pumping structures to deliver the leachate to a storage and treatment area.

The mechanisms of contaminant migration from the containment cell are advection and chemical diffusion. Advection or solute diffusion is the movement of the solution in the soil pores under a hydraulic gradient, the difference in hydrostatic head between two points. The rate of flow is also governed by the hydraulic conductivity or permeability of the medium through which flow occurs. Chemical diffusion is a transport process in which a chemical or chemical species in solution flows in response to a gradient in its concentration. Pollutants will migrate from a point of high concentration to a location with a low concentration of the chemical. Diffusion is significant at the relativity low seepage velocities occurring in landfill liners and may in some cases be the dominant transport mechanism.

The liner barrier materials consist of soil liners and/or man-made geosynthetics. Soil liners may consist of a natural insitu clay soil of low permeability or hydraulic conductivity and sufficient thickness to meet the required criteria for leachate control. If an insitu clay soil has too great a hydraulic conductivity, it can be excavated and recompacted in dense layers in a thickness to achieve or exceed the target permeability.

Natural clay liners can have higher bulk permeability than those indicated by lab or field testing. Granular seams and cracks or fissures in the natural soil fabric can cause "short circuits" through the soil barrier. Tilling and recompaction of the clay can close any fractures and granular seams or pockets can be excavated. In this way a liner with more uniform properties can be achieved. On the negative side, the natural structure of the clay is disrupted and it is not possible to achieve as low a permeability as in an intact, naturally deposited clay.

Clay soil liners have benefits in the impedance of molecular diffusion. The interparticle forces of the clay can attract some cations resulting in attenuation, slowing the rate of diffusion. However, some studies have shown that certain alkaline solutions and hydrocarbons can interact with clay resulting in increased permeability of the clay liner.

If suitable clay soil is not found at the proposed site, clay can be imported from borrow sources to be compacted in lifts in construction of the liner. When clay borrow sources are not located within economic trucking distances, the insitu soil can be excavated and mixed with bentonite and recompacted. Bentonite is a form of montmorillonite clay and has a high swelling capacity. The bentonite is supplied in a powder or granular form. When well mixed, in the proper quantities, the soil-bentonite mixture can be compacted in lifts to achieve a liner of the required thickness and low permeability.

Another option, when the native soils are not acceptable or not in sufficient quantity to be used in construction of the liner, is to use a man-made geosynthetic, flexible membrane liner (FML). The most frequently used FML types are linear low-density polyethylene (LLDPE) and high-density polyethylene (HDPE). Other FML types include chlorinated polyethylene (CPE), chlorosulfonated polyethylene (CSPE) or Hypalon and polyvinyl chloride (PVC).

The HDPE liner is becoming the most common choice of FML for waste containment. Some problems are inherent in the use of the other materials. PVC liners can become brittle if the plasticizers, used to create flexibility, leach out. This can happen when PVC liners are exposed to sunlight, microbes and/or effluents. Hypalon is used as a liner when reinforced with a scrim fibre laminated between two layers of polymer. The scrim provides the strength for Hypalon but the polymer itself has much lower physical strength than either HPDE or PVC. The scrim causes Hypalon to have low elongation capacity and also provides the possibility of delamination. If delamination occurs, the scrim can act as a wick transmitting the effluent throughout the membrane. CPE liners have poor durability and strength and since it also contains plasticizers to impart flexibility, it is also vulnerable to the same problems affecting PVC. The LDPE liner has a lower density than the HDPE liners, which indicates a lower level of crystallinity. The decrease in crystallinity makes it more susceptible to acids, caustics and oil. Also due to the lower density, the methane permeation and water vapour transmission rates are higher and the physical properties less than the HDPE liner.

Selection of the appropriate geosynthetic liner for the waste containment cell would be based on performance requirements. These include the service life of the cell, the required life for performance after closure and regulatory requirements. Also considered are the characteristics of the leachate such as chemical constituents and the compatibility of the liner material. Environmental conditions to which the liner will be exposed such as temperature extremes, rainfall, wind and sunlight are also considered.

The purpose of the leachate collection and removal system is to detect the presence of liquids at the base of the landfill and to enable removal of those liquids.

A primary collection system is located at the base of the cell above the containment system. This collects and removes the leachate generated from water infiltration percolating through the overlying wastes. Typical components of this collection system are granular drainage layers sloped to collection pipes leading to sumps in low points on the base liner. The leachate is pumped through pipes from these sumps to the storage and treatment system. Riser pipes can be included to allow access to the piping to enable prevention of clogging of the collection system.

A secondary collection system can also be provided to allow detection and collection of any liquid below or between components of the liner system.

Waste containment systems can be single liner or double liner systems. A double liner system is a more secure system than the single liner system, however, it should be noted that it may be unecessary in some geologic or geographic locations.

The basis for selection of a double liner system is the assumption that geotextile liners will have some leaks after installation. In a double liner containment system, a secondary liner is installed beneath a protective layer placed below the primary liner, which is intended to provide a suitable bearing surface for the primary liner.

The primary leachate collection system placed above the primary liner is the first mechanism to prevent migration of leachate through the leaks. This system removes the leachate generated in the landfill cell so it does not build up inside the cell, which would create a hydraulic head promoting flow through any leaks in the liner. Over the service of the landfill the primary leachate collection system may become plugged due to bacterial growth or sediment build-up. In this case, the presence of the secondary leachate collection system would actually promote leachate flow through leaks in the primary liner, however, this would be collected for treatment and disposal. The secondary leachate collection system may help to locate leaks in the primary liner. The extra security of the double liner system is that the location of leaks in the primary liner may not coincide with the locations of leaks in the secondary liner in such a way to be hydraulically connected. Also, the time for the secondary leachate collection system to plug up, as well as the primary collection system, may be greater.

In geologic site conditions, such as the three sites under consideration, where the liner is underlain by a clayey soil of low permeability, the liner and underlying soil act as a composite system. If the level of leachate does build up in the cell the migration of leachate through leaks in the geotextile liner would be slowed or contained by the low permeability and attenuation properties of the till.

Another consideration for the type of liner system required is the geographic location of the landfill site. What potential areas of impact are located down gradient and will any migration of contaminants be at toxic levels when they reach these points. The natural dispersive, attenuative and bacterial properties of the subsurface environment may contain any potential containment migration from the landfill site.

The New Brunswick design guidelines for sanitary landfill sites specify a liner with one of the following characteristics:

1) a natural uncompacted liner shall consist of a CL soil and have a minimum thickness of 10 meters and maximum permeability of 5×10^{-7} cm/sec;

2) a recompacted clay liner will be a CL soil with a minimum thickness of 2 meters and a maximum permeability of 1×10^{-7} cm/sec;

3) a geomembrane with a minimum thickness of 50 to 60 mils and a maximum permeability of 1×10^{-10} cm/sec underlain by a soil layer with a maximum permeability of 1×10^{-4} cm/sec and a minimum thickness of 600 mm;

4) insitu soil can be mixed with bentonite to achieve a soil-bentonite mixture 150 mm thick with a maximum permeability of 1×10^{-4} cm/sec.

At the three potential sites, the amount of suitable clay till is insufficient to meet regulatory requirements for a natural insitu barrier. Based on the knowledge and experience in the area, there is no economical source of clay borrow material to import material for a suitable clay soil liner. For these reasons, a geosynthetic membrane will be utilized in the containment system. Optimizing the design of the containment system for the Westmorland/Albert Regional Solid Waste Facility should consider the barrier properties of the insitu till at the three sites under consideration. A double liner containment system would be theoretically suitable for siting a landfill facility in a sand and gravel stratum above an aquifer. Use of a double containment system in the landfill cells at the chosen site would not take advantage of the natural attributes of the site. In addition, the double liner system could nearly double the cost for materials and construction of each cell developed at the facility.

Optimization of the design of the landfill cell will utilize the native till in a composite liner system with the installed geotextile liner. The minimum required thickness of the till layer, to act as a second liner, will be determined. Preparation of the glacial till subgrade for placement of the FML will entail tilling the top of the soil, removing any cobbles and boulders, followed by grading and re-compaction to achieve a smooth surface and design grades. Recompaction of the glacial till will serve to close any natural fractures in the insitu soil and further reduce the hydraulic conductivity of the till. Placement of the FML will be subject to state-of-the-art quality control inspection to ensure the product is as intact as possible. If imperfections in the geosynthetic liner do occur, the low permeability and attenuation properties of the glacial till will serve to act as a second barrier to contaminant migration. In this way a double containment system will be achieved without the added cost of the double liner system.

The leachate collection system will act to remove leachate from the bottom of the containment cell preventing the build-up of hydrostatic pressure to increase the hydraulic gradient through the containment system. The collection drains will include access for cleanout to prevent clogging of the drains. No secondary collection system will be necessary.

3.3.6.3 Treatment

In the report entitled "Septage Disposal in New Brunswick", it was recommended that a properly designed lagoon system for septage and leachate disposal be considered for each of the proposed sanitary landfill sites in the province. If an on-site treatment system were the preferred option, the design of the treatment system must be postponed until leachate production and quality are determined. During this time leachate could be treated using a temporary option, such as recycling of the leachate into the landfill and aerating in ponds.

In general, the options for treatment of landfill leachate may be summarized as follows:

- site attenuation;
- discharge to municipal waste water treatment plant (WWTP), with or without on-site pre-treatment;
- on-site recycling; and
- full, on-site secondary treatment for discharge of treated effluent to a watercourse.

The site attenuation option basically uses the microbiological community of the soil around the landfill to provide for treatment of the landfill leachate. Naturally, this option requires that the landfill be located in an area where soil and groundwater conditions are suitable. Under the Province of New Brunswick's guidelines for regional sanitary landfills, the site attenuation option is not acceptable. The guidelines specify that leachate is to be collected and treated.

Discharge of leachate to the municipal WWTP, when available, is the preferred treatment option. This approach can provide the lowest overall cost for leachate management because a new treatment plant is not required, although operating costs at the existing municipal WWTP would increase. Direct discharge of landfill leachate to the municipal WWTP is possible when:

- the municipal WWTP is a secondary treatment plant with enough capacity to handle the leachate load;

- the leachate does not unduly stress or inhibit operation of the municipal WWTP.

If the municipal WWTP is a primary treatment plant, such as the new Moncton plant, then the leachate should be aerobically pretreated, on-site, to reduce BOD.

A common initial treatment of leachate is to recycle the leachate through the landfill cell. If this method is used, the cell(s) will have to be designed with special infiltration galleries. This method does, however, have several drawbacks. The amount of leachate produced might exceed the absorption capacity of the landfill and reduction of leachate strength may not be sufficient to meet effluent standards. Odour problems may also result from this method. For these reasons, at least partial treatment of the leachate may be required. There is also the possibility that recycling will lead to the accumulation of metals in the leachate.

The actual performance of the landfill will determine the feasibility of recycling and the type of leachate treatment to be applied. Where recycling of leachate is not feasible, the option is to provide an on-site, dedicated, secondary treatment plant. A variety of biological or physical-chemical treatment methods are available, as well as combinations of both. The most common leachate treatment methods are summarized below.

A) Biological Treatment

The fundamental mechanisms involved in biological treatment are the same for all processes. Microorganisms, principally bacteria, utilize organic material and inorganic ions present in wastewater to support growth. A portion of the material is oxidized, and the energy released is used to convert the remaining material into new cell tissue. The oxidation reactions are collectively referred to as "catabolism", and the production or synthesis of new cell tissue is called "anabolism". Catabolism and anabolism, while conceptually different, are coupled together in many ways, and the combined processes are known as "metabolism".

Biological systems offer the advantage of high removal rates and cost efficiency. However, their performance is temperature dependant and reduced efficiency can be expected during the winter months, unless provisions for heating are made in the design of the treatment systems. The strong toxicity which can be expected from the leachate (e.g. from high metal concentrations) may possibly have adverse effects on the performance of a biological system.

Biological treatment processes can be classified in a number of ways. Common divisions are aerobic and anaerobic, i.e., according to metabolic activity, and suspended and attached growth, i.e. according to the location of the microorganisms.

Aerobic and Aerated Lagoons

In aerated lagoons, oxygen is supplied from surface aeration, photosynthesis or bubble aeration. The maximum BOD_5 loading rate is 0.05 $kg/m^3/day$ for complete treatment and 0.15 $kg/m^3/day$ for partial treatment. Hydraulic retention times for leachate are reported to be 30 to 60 days, compared to 10 to 15 days for municipal wastewater.

Multi-cell aerated lagoons maximize BOD removal efficiency. It is also possible to improve aerated lagoon efficiency by covering some, or all, of the aerated cells to minimize heat loss.

Activated Sludge Process

The activated sludge process is probably the most versatile and effective of all waste treatment processes. Due to the high BOD loadings of leachate, the activated sludge process has often been used to treat landfill leachate.

During the activated sludge process, microorganisms in the aeration tank convert organic material in the leachate to microbial biomass and CO_2. Organic nitrogen is converted to ammonium ion or nitrate. Organic phosphorus is converted to orthophosphate. The microbial cell matter formed as part of the waste degradation process is normally kept in the aeration tank until the microorganisms are past the log phase of growth, at which point the cells flocculate relatively well to form settleable solids. These solids settle out in a settler and a fraction of them is discarded. Part of the solids, the return leachate, is recycled to the head of the aeration tank and comes into contact with fresh leachate. The combination of a high concentration of "hungry" cells in the return leachate and a rich food source in the influent leachate provides optimum conditions for the rapid degradation of organic matter.

The activated sludge process provides two pathways for the removal of BOD; BOD may be removed by (1) oxidation of organic matter to provide energy from the metabolic processes of the microorganisms, and (2) synthesis, incorporation of the organic matter into cell mass.

BOD_5 loading rates of activated sludge plants should not exceed 0.15 $kg/m^3/day$ for complete treatment and 0.5 $kg/m^3/day$ for partial treatment (70 percent removal).

Other Aerobic Treatment Systems

Other biological treatment systems available for the treatment of leachate are **Rotating Biological Reactors**, and **Trickling Filters**. Both are examples of fixed-film biological (FFB) process.

Rotating biological reactors consist of groups of large plastic discs mounted close together on a shaft. The device is positioned such that half of each disc is immersed in leachate and half exposed to air. The shaft rotates constantly, so that the submerged portion of the discs is always changing. The discs, usually made of high-density polyethylene or polystyrene, accumulate thin layers of attached biomass, which degrades organic matter in the leachate. Oxygen is absorbed by the biomass and by the layer of leachate adhering to it during the time that the biomass is exposed to air.

The **trickling filter** is a process in which leachate is sprayed over rocks or other solid support material covered with microorganisms. The structure of the trickling filter is such that contact of the leachate with air is allowed and degradation of organic matter occurs by the action of the microorganisms.

Anaerobic Lagoons or Digesters

Anaerobic treatment processes are used almost exclusively for high BOD concentration wastewaters, such as landfill leachates. These processes have the advantage of a slow build-up of solids, hydraulic retention times of 10 to 15 days and the generation of methane.

During the anaerobic fermentation process, soluble complex organic materials are oxidized to low-molecular-mass organic acids, including acetic acid, the principal precursor of methane. Hydrogen gas is also produced. A symbiotic relationship exists between the bacteria using the H_2 and CO_2 to produce CH_4 and those splitting acetic acid. The principal methane fermenting reactions are listed below:

$$H_2 + 1/4\ CO_2 \rightarrow 1/4\ CH_4 + 1/2\ H_2O$$

$$CH_3COOH \rightarrow CH_4 + CO_2$$

In typical methane fermentation systems, 60 to 70 percent of the gas produced (by volume) will be methane, with most of the remainder being CO_2. Methane fermentation rates decrease sharply at temperatures below 30°C and at pH values below 6.5 and above 8.5.

B) Physical-Chemical Treatment

In order to reduce the toxic effects of the leachate, physical-chemical treatment might be applied before the biological treatment.

Coagulation and Flocculation

The addition of coagulants or flocculation aids to the leachate before it enters the settling basins allows suspended solids (which cannot be removed using simple sedimentation) to come closer together and form flocs which settle before they enter receiving waters. The addition of such aids has also been shown to be able to remove metals, colour and COD. Common flocculation aids are lime, $FeClSO_4$, $FeCl_3$, Alum ($Al_2(SO_4)_3$) and organic polymers. Coagulation processes are often pH dependent and a pH adjustment of the leachate might be required.

Other Physical-Chemical Processes

A variety of other physical-chemical processes have been applied to landfill leachate, including ion exchange, carbon absorption, reverse osmosis and chemical oxidation. However, most of those systems have been tried only under laboratory or pilot plant conditions. High costs and lack of full scale experience make those options unattractive for the proposed landfill operation.

Factors Affecting Leachate Treatment

There are a number of possible operating factors at a solid waste disposal facility that can have very significant effects on leachate quantity, composition and treatment including:

- leachate recycle to the landfill
- shredding of refuse
- baling of refuse
- compaction density
- wastes directed to recycling or composting
- addition of sewage sludge to the landfill
- capsizing frequency/strategy at the landfill

A landfill leachate treatment plant, although not really required until sometime after the start of the landfill, will be required long after the landfill itself is decomissioned. Expected leachate flows and strength after landfill completion will vary depending on the capping strategy and whether or not leachate recirculation is practised. Based on a capping strategy of where cells are capped after 5 years and recycle is practised, landfill leachate BOD should reach its maximum at approximately the same time as daily flows peak. It is expected that the maximum leachate BOD would be approximately 12000 mg/l and peak flow would be 36 m^3/l.

Preliminary Leachate Treatment Design

There are two leachate treatment options identified: modified aerated pretreatment lagoon; and a complete treatment option composed of physical chemical treatment, followed by anaerobic and aerobic treatment in sequence. Since the treated effluent can be piped to the municipal sewer from the Berry Mills Road Site and Delong Drive Site and trucked from the Route 126 Site, followed by further treatment in the Greater Moncton Sewage Commission plant, the greater expense and operational difficulties of the complete treatment option is not necessary.

The pretreatment system would be an aerated lagoon system with the following features:

- 4 equal volume cells with baffled intra-cell divisions
- surface self-aspirating type aeration
- option to cover the cells
- quiescent zone in final cells for solids settling; and
- designed to meet levels of 600 mg/l of BOD and 500 mg/l of SS

A total lagoon volume of 1600 m^3 with a total aeration horsepower of 50 would be suitable for design flow and loadings of 40 m^3/d and 450 by BOD/d respectively. The lagoon system should easily meet the BOD and SS limit. If metals concentrations in lagoon effluent were too high, then a lime addition system would be used to improve metals precipitation. Also extra aeration would be added if conversion of ammonia to nitrate was required.

The effluent discharged to the City sewer and the Greater Moncton Sewage Commission Plant will meet their bylaw requirements for discharge to these systems.

No leachate will be discharged to nearby surface water bodies. A leachate holding pond will be constructed with the development of the first landfill cell and construction of the leachate pretreatment system will be started in the second year of operation.

Effluent from the pretreatment operation will be conveyed to the Greater Moncton Sewage Commission Pollution Control Plant for further treatment. This plant which is expected to be fully operational in 1993 is a "chemically assisted" primary treatment plant with sludge dewatering of the raw primary sludges. The plant layout was to be such that secondary treatment, disinfection and anaerobic digestion would be added in the future if required. The plant design parameters are an average daily dry weather flow of 115210 m^3/d a raw sewage BOD of 100 mg/l and suspended solids of 75 mg/l. The anticipated removals are up to 70% of both BOD and suspended solids. The effect of the effluent discharged from the pretreatment plant at the landfill will be negligeable. The dillution faction obtained in the sewer system before entering the GMSC plant is very large (> 2800 to 1) and with the removal of most of the BOD in the leachate pretreatment system, the increase in BOD loadings to the GMSC plant is very small (<0.5%).

The effluent from the pretreatment plant can be piped to the existing City sewer system from both the Delong Drive and Berry Mills Road sites. Although the exact routing is not known, the distances involved are 2 km and 4 km respectively. Appropriate design guidelines, such as those prepared by the N.B.D.O.E. and others, will apply to the piping system design. A pumping station will be required for both of these sites. It is expected that it will be located at the sites near the pretreatment system. Standby power would not be required as the holding capacity of the system will be sufficient to prevent any overflows during temporary loss of power. Leachate from the Route 126 Site would be trucked to the City sewer system.

3.3.7 CONTROL OF GAS EMISSIONS

Biological decomposition of waste in landfills under anaerobic conditions produces a gaseous byproduct commonly called landfill gas or biogas. The major components are carbon dioxide and methane which together account for approximately 97% of the gas. In particular, methane can accumulate, migrate laterally and pose a serious fire or explosion hazard. Methane can also kill cover vegetation when root zones are exposed to the gas.

In addition to carbon dioxide and methane, it is known that volatile organic compounds are emitted from landfills but, to date, the full scope or magnitude of this contamination is not known.

Due to the present urgency to protect the atmosphere from greenhouse gases and ozone depleting chemicals, control measures for the generation and emission of landfill gas, particularly methane, must be implemented.

3.3.7.1 Gas Generation

To determine the amount of methane gas produced by a landfill is very difficult; however, it is possible to estimate the gas production rates, based on empirical data and experience with other sites. It is important to remember that such methods are based on historical experience with the composition of refuse, and could be subject to changes due to future conservation and recycling programs that change the composition of the waste. It is also recognized that many factors such as moisture level, contaminants, infiltration and consolidation will influence the process of waste breakdown in a given landfill, so that predictions of gas flows are to be regarded as very rough approximations of what can be expected in the real world.

It has been estimated that 30% of typical refuse organic content is of the rapidly decomposing variety, and its half life (time to breakdown half of the material remaining) will be in the 1 to 5 year range. That is, if a half life of 3 years were assumed, then after 3 years, only half of this component would remain to be decomposed. After another 3 years, 25% of this component would remain and so on.

Similarly, 70 percent of the organic component is generally conceded to be in the intermediate rate category with a half life of 5 to 25 years, and a 90% decomposition time of between 20 to 100 years.

However, it is anticipated that with recycling and reduction programs such as composting, the total percentage organic refuse destined for landfilling at the proposed facility will be less than 10%.

The rate of decomposition is influenced not only by the composition of the waste, but also by the moisture level maintained in the waste. Moisture in the range of 70 to 80% by weight is optimal for gas production, but waste is typically placed at a moisture content much lower than this. The ultimate moisture content is a function of local rainfall as well as landfill design and leachate handling systems. The acidity of the environment is another factor since pH levels below 6 will inhibit anaerobic activity. Leachate recycling systems can be used to maintain moisture levels in the buried landfill waste, although these are the subject of some controversy in the U.S., where the E.P.A. has leaned to the position that redeposit of leachate at its source constitutes the deposition of a liquid waste product.

Recent research in Great Britain has documented the significant effect that atmospheric pressure has on the production of landfill gas. Recorded gas flows increase substantially during periods of low atmospheric pressure.

Landfill gas consists primarily of methane and carbon dioxide in variable proportions totalling approximately 97% for a typical site. Methane typically ranges from 40 to 60% of the total.

Over the life of a landfill, one tonne of mixed municipal waste may be expected to produce 186 to 250 cubic meters of methane gas based on theoretical and empirical data. Given all these empirical rules, a simplified mathematical model can be constructed to estimate the rate of methane production over time for a given site.

3.3.7.2 Derivation of Gas Generation Model for Landfill

Assumptions:

1. Material has a constant 1/2 life. i.e. every x years, 1/2 of the volatile matter will produce a quantity of gas. During the next x years 1/2 of the remainder will be used up.
2. Total quantity of gas is fixed per kg. of material (i.e. area under the gas production vs time curve)

Formula for 1/2 life gas production:

where t = 1/2 life period in years
k = a constant index of methane production per unit of raw material.

gas production = $k \times 2^{-x/t}$

total gas production $Q = \int_{x=0}^{\infty} k \times 2^{-x/t}\,dx$

$$= k \Big|_{x=0}^{\infty} 2^{-x/t}/(1/t) \times \ln 2$$

$$Q = k \times t/\ln 2$$

If Q = 200 total cubic meters per tonne of material and half life = 5 years then k = 200 x ln2/5 or in general:

$$k = Q \times \ln 2/t$$

Based on these equations, a computer model has been generated to produce an estimated profile of total gas production over the projected life of the Westmorland/Albert landfill. A composite graph of gas flows is presented as Exhibit 3-2. This graph assumes typical historical composition of municipal solid waste as outlined below. Should the composition and quantities change due to adoption of recycling, composting or other measures, then the assumptions in the model can be altered to reflect the anticipated situation and produce a modified estimate.

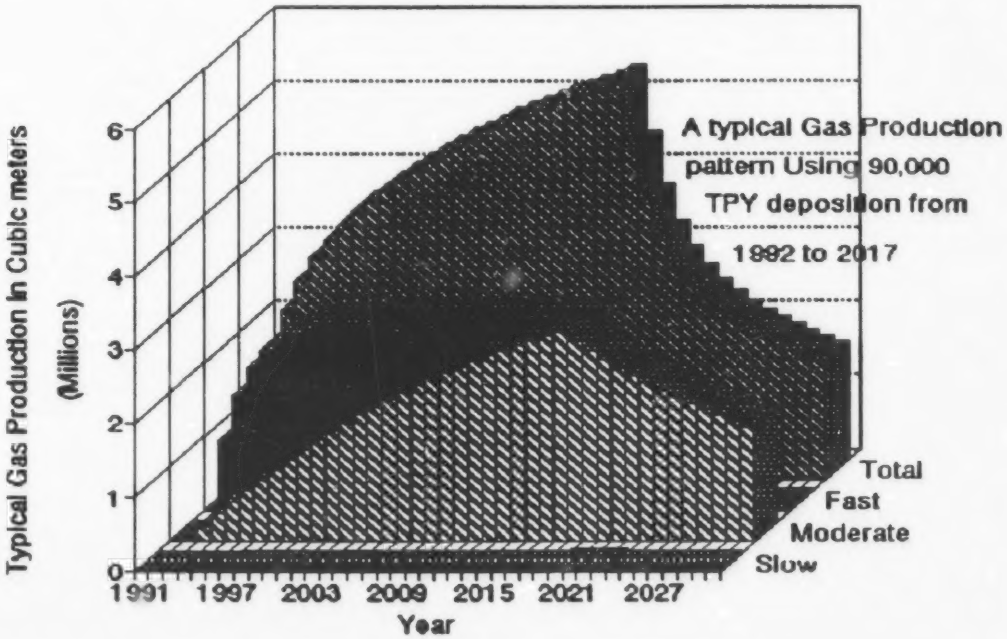


EXHIBIT 3-2: Preliminary Landfill Gas Production Model

The graph is based on the annual deposition of 90,000 tonnes of Municipal solid waste for a 25 year period beginning in 1992. It is apparent that the total gas generation will diminish rapidly as soon as the landfill is filled, but that significant gas production will persist for many years due to the breakdown of slower biodegradables such as paper products.

3.3.7.3 Landfill Design for Gas Extraction

Many of the design requirements to optimize the recoverability of landfill gas are compatible with good landfill practices even where gas recovery is not considered a priority.

To begin the construction process, a sealed bottom and sides for a "cell" is created with provision for piped drainage of leachate to a controlled location for processing and treatment as necessary. In order to dispose of the Westmorland/Albert Region's waste, cell dimensions will be approximately 6 hectares by at least 15 meters deep.

MSW will then be deposited in compacted lifts of 20 m long x 8 m wide x 3 m high, followed by a thin layer of soil. When the cell is filled, it will then be capped with an impervious layer of clay soil up to a meter deep to act as a top seal. As long as the top seal remains moist, a good seal will be maintained.

As a minimum, five vertical gas wells will be installed for each hectare of waste disposal area. These gas wells can be drilled into the cell or built as the lifts are developed. The plastic casing of 150 mm diameter will be placed in the centre of the borehole in a 20-40 mm permeable backfill such as pea gravel, and the pipes will have 6 mm holes drilled in 3 rows staggered approximately 300 mm apart, starting below the final soil cover. The pipes will be placed in telescoping sections to allow for the settling of the landfill that will take place due to mechanical compaction and waste decomposition.

Gas collection piping will be attached to the wells and will transfer the gas to a single point source from where it will be flared (waste burned). Burial of the collection pipe has the advantage of protecting it from mechanical damage, and minimizing problems with condensation of water vapour in the collection piping.

Condensate collection points will be provided for the gas collection piping at all low points since the landfill gas is typically saturated with moisture at the point of origin. Because the temperature of the gas is quite high due to the biological action in the waste, the gas contains a significant quantity of moisture which would condense in the collection lines as the gas cools. The condensate could be collected at designated low points in the lines and be recycled into the landfill using a drain field, for example.

3.3.7.4 Uses for Landfill Gas

Landfill gas produced at the Westmorland/Albert Integrated Waste Management Facility will initially be vented, followed when a buildup occurs by burning in a flare so as to eliminate problems with odours, and to prevent reaction of methane with atmospheric ozone. This is certainly better than releasing the landfill gas to atmosphere, but if it is economically feasible to do so, it is much better from a global environmental perspective, to recover useful energy from the gas being burned so as to displace conventional fossil fuel energy sources with the otherwise wasted combustion of landfill gas. Should a decision be made to collect and use the landfill gas, the following gas handling systems used by others may apply.

The gas can be burned as a source of heat in a process boiler or dryer of some type. In larger centres, landfill gas is used as dryer fuel for the sterilization and drying of municipal sludge which can then be sold as an additive for commercial fertilizers, or even as a supplementary fuel for wood burning installations where no market exists for the fertilizer product.

Landfill gas can be cleaned and separated into commercially valuable carbon dioxide and methane, but this is not likely to be an economical proposition for the Westmorland/Albert landfill.

At some large landfill sites, stationary gas engines or turbines are used to generate electric power from landfill gas. The economics of power generation are sensitive to electric power costs and to the size of the engine which can be supported. In order to make this option economically viable, the revenue received from the electrical utility has to be substantial.

3.4 Site Closure and Reclamation

As the capacity of a portion of the cell is reached, material of low permeability (at least 10^{-6} cm/sec) from the on-site borrow pits will be used for capping. The final cover will be approximately 1 m in thickness. The capping will be followed by the seeding of the surface. By the time the landfill is closed, therefore, most of the surface will have already been prepared. The reclaimed areas are expected to settle somewhat as the buried garbage decomposes. Thus, periodic maintenance will be required to ensure the integrity of the final cover over the garbage and to eliminate any areas where ponding of precipitation could occur.

The end use of the landfill site is limited even in the best of conditions. Post-closure uses are usually restricted to open space areas or to undeveloped parks. Uses requiring irrigation (e.g. golf courses) are undesirable because they increase the amount of water entering the fill, increasing in turn, the potential for leachate production. The need to maintain the slope of the cover eliminates other uses such as for sports fields which require flat surface areas.

The final use after closure will depend on which of the three potential sites is chosen for the facility location.

Since the Delong Drive Site and Berry Mills Road Site are located adjacent to the City of Moncton Industrial Park, it is probable that industrial and commercial developments will occur in the area surrounding the facility. For this reason, the final use of the facility may take the following forms: greenhouse, horticultural production area, nursery, open storage areas or parking facilities.

The development of the sites will be such that unfilled space will be left between working cells and this could be used for the buildings which may be required by the industrial or commercial developments.

The area surrounding the Route 126 Site generally consists of trees, the Cocagne River, Indian Mountain and several small brooks. The area around the site is presently undeveloped and it is unlikely that this area will be developed in the next 25 years. For this reason, the site may be an ideal location for passive recreation activities, such as pedestrian/cross country ski trails, interpretative trails, outdoor education, viewing areas and picnic areas. This would permit good family activities for the entire year.

Similar to the other two sites, development will be such that unfilled space is left between working cells for placement of any buildings. Any restrictions limiting use by wildlife will be removed upon closure of the site.

Monitoring of the site and surrounding water courses will continue for many years. The post-closure monitoring program will be the responsibility of the WASWPC but will meet N.B.D.O.E. approval. The leachate treatment system will have to remain operational until the strength of the leachate diminishes to a point where it can be discharged directly to the receiving stream.

4.0 ASSESSMENT OF ENVIRONMENTAL IMPACTS

The principal objectives of the Environmental Impact Assessment are (1) to identify interactions between the natural and socio-economic environment (as described in Chapter 2) and activities associated with the project (as described in Chapter 3); (2) to predict the impacts (those interactions considered to be serious) which can be expected; and (3) to identify methods of mitigating negative impacts, as well as the potential for impacts after mitigation is in place.

4.1 Identification of Issues

The screening of impacts was done for the construction, operational and closure/post-closure phases of the proposed waste management facility. Exhibits 4-1, 4-2 and 4-3 present the impacts for the three sites under consideration.

The interactions encountered in these grids can be separated into four categories: no impact, minimal impact, possible impact and definite impact. The two last categories are subject to further discussion in upcoming sections. In many cases, the reasons for identifying no impacts are self-evident; in other cases, the decision was made based upon knowledge of the project and the local area by members of the project team. For both the Delong Drive and Berry Mills Road Sites, the possible impacts were determined to be negative and the definite impacts were determined to be positive. For the Route 126 Site, the definite impacts on wildlife habitat were determined to be negative.

The proposed Westmorland/Albert Integrated Waste Management Facility will be designed to contain and treat leachate and surface runoff, so that effluent will meet standards to protect fish and fish habitat. It is therefore anticipated that the containment design will prevent contamination of the groundwater resource and that collection and treatment will prevent adverse impacts to aquatic resources. No leachate will be discharged to surface or groundwater bodies.

No containment system can guarantee one hundred percent effectiveness. In fact, human error or unusual natural conditions (e.g. a heavy rain storm washing out a dike) may cause accidental releases. Should accidental releases occur, discussions on possible impacts on the quality of surface watercourses, as well as on aquatic resources are presented in Sections 4.3 and 4.5 respectively. These sections also present a background for the design of monitoring programs and for contingency planning.

Although construction activities will also affect surface watercourses and aquatic resources, the anticipated change would not be significant (not considered serious), providing control measures are effective in meeting water quality standards.

RESOURCES	CONSTRUCTION					OPERATION				CLOSURE & POST-CLOSURE
	ROAD CONSTRUCTION	CLEARING & GRUBBING	DRAINAGE WORKS & DISPOSAL AREAS	DEVELOPMENT OF BORROW AREAS	BUILDING & SERVICES	TRUCKING OF WASTE	SITE DRAINAGE	EXCAVATION OF COVER MATERIAL	DISPOSAL OF WASTE	
WATER AVAILABILITY										
GROUNDWATER QUANTITY										
GROUNDWATER QUALITY							▨		▨	▨
SURFACE WATER QUANTITY			▩	▨			▩	▨		
SURFACE WATER QUALITY			▨	▨			▨	▨	▨	▨
WILDLIFE HABITAT		▩	▩	▨						
AQUATIC RESOURCES										
FISH HABITAT										
FISH FOOD										
FISH MIGRATION										
SOCIO-ECONOMIC										
HEALTH AND SAFETY						▨			▨	▨
NUISANCE/NOISE						▨			▨	
EMPLOYMENT	▧	▧	▧	▧	▧	▩		▧	▧	▧
LAND/RESOURCES USE										▧
LAND VALUES										
RECREATION										
AESTHETICS						▨				

LEGEND ☐ : NO IMPACT ▩ :MINIMAL IMPACT ▨ : POSSIBLE IMPACT ▧ : DEFINITE IMPACT

FOR THIS SITE, POSSIBLE IMPACTS WERE DETERMINED TO BE NEGATIVE AND DEFINITE IMPACTS WERE DETERMINED TO BE POSITIVE.

EXHIBIT 4-1 : INITIAL IMPACT SCREENING - DELONG DRIVE SITE

RESOURCES	CONSTRUCTION					OPERATION				CLOSURE & POST-CLOSURE
	ROAD CONSTRUCTION	CLEARING & GRUBBING	DRAINAGE WORKS & DISPOSAL AREAS	DEVELOPMENT OF BORROW AREAS	BUILDING & SERVICES	TRUCKING OF WASTE	SITE DRAINAGE	EXCAVATION OF COVER MATERIAL	DISPOSAL OF WASTE	
WATER AVAILABILITY										
GROUNDWATER QUANTITY										
GROUNDWATER QUALITY							▨		▨	▨
SURFACE WATER QUANTITY	▩		▩	▨			▩	▨		
SURFACE WATER QUALITY	▨		▨	▨			▨	▨	▨	▨
WILDLIFE HABITAT	▩	▩	▩	▨						
AQUATIC RESOURCES										
FISH HABITAT			▨	▨			▨		▨	▨
FISH FOOD			▨	▨			▨		▨	▨
FISH MIGRATION			▨	▨			▨		▨	▨
SOCIO-ECONOMIC										
HEALTH AND SAFETY						▨			▨	▨
NUISANCE/NOISE						▨			▨	
EMPLOYMENT	▧	▧	▧	▧	▧	▩		▧	▧	▧
LAND/RESOURCES USE										▧
LAND VALUES										
RECREATION	▩	▨	▨	▩			▨	▩	▩	
AESTHETICS						▨				

LEGEND ☐ : NO IMPACT ▩ :MINIMAL IMPACT ▨ : POSSIBLE IMPACT ▧ : DEFINITE IMPACT

FOR THIS SITE, POSSIBLE IMPACTS WERE DETERMINED TO BE NEGATIVE AND DEFINITE IMPACTS WERE DETERMINED TO BE POSITIVE.

EXHIBIT 4-2 : INITIAL IMPACT SCREENING – BERRY MILLS ROAD SITE

RESOURCES	CONSTRUCTION					OPERATION				CLOSURE & POST–CLOSURE
	ROAD CONSTRUCTION	CLEARING & GRUBBING	DRAINAGE WORKS & DISPOSAL AREAS	DEVELOPMENT OF BORROW AREAS	BUILDING & SERVICES	TRUCKING OF WASTE	SITE DRAINAGE	EXCAVATION OF COVER MATERIAL	DISPOSAL OF WASTE	
WATER AVAILABILITY										
GROUNDWATER QUANTITY										
GROUNDWATER QUALITY							▨		▨	▨
SURFACE WATER QUANTITY	▩		▩	▨			▩	▨		
SURFACE WATER QUALITY	▨		▨	▨			▨	▨	▨	▨
WILDLIFE HABITAT	▩	▧	▧	▧		▨				
AQUATIC RESOURCES										
FISH HABITAT			▨	▨			▨		▨	▨
FISH FOOD			▨	▨			▨		▨	▨
FISH MIGRATION			▨	▨			▨		▨	▨
SOCIO–ECONOMIC										
HEALTH AND SAFETY						▨			▨	▨
NUISANCE/NOISE						▨			▨	
EMPLOYMENT	▧	▧	▧	▧	▧	▩		▧	▧	▧
LAND/RESOURCES USE										▧
LAND VALUES										
RECREATION	▩	▨	▨	▩			▨	▩	▩	▨
AESTHETICS						▨			▨	

LEGEND ☐ : NO IMPACT ▩ :MINIMAL IMPACT ▨ : POSSIBLE IMPACT ▧ : DEFINITE IMPACT

EXHIBIT 4–3 : INITIAL IMPACT SCREENING – ROUTE 126 SITE

The possible and definite impacts on wildlife habitat are discussed in Section 4.4. Construction activities are seen as reducing wildlife habitat.

Regarding the socio-economic system, the construction, operational and closure/post-closure phases of the project will have a definite positive impact on employment, as a small number of jobs will be created. No impact is foreseen on land use and resources.

The impact issues arising from the initial screening of impacts are the following:

- Nuisance, noise and safety effects on residences along the possible haul routes from trucking the waste.
- Increase in nuisance animals due to the presence of a landfill.
- The potential effects from the creation of a borrow area.

Should containment or treatment of effluent fail, the following impacts may occur. These releases would not be expected to occur on a regular basis, but may occur occasionally throughout the life of the facility.

- Increased suspended sediment loadings to Michael's Creek Somers Creek, or the Cocagne River which could affect aquatic life.
- Contamination of Michael's Creek, Somers Creek or the Cocagne River which could affect water quality and aquatic life.
- Contamination of groundwater which could in turn contaminate surface watercourses.

Given the topography of the Route 126 Site and the proposed location of the sedimentation ponds, no increased sedimentation is expected to occur in Shaw Brook, nor is the water quality expected to be impacted.

Increased sedimentation may occur in Jonathan Creek and the Cocagne River tributaries due to access road construction.

The following sections present a more detailed investigation of each of the impact issues. Potential impacts are identified, and mitigation measures are proposed where practical. Monitoring programs are proposed to detect the presence of new impacts.

4.2 Groundwater Resources

The groundwater resources in the study areas are currently used as a source of potable water. Wells drilled into the bedrock aquifer represent the primary source of supply. The till aquifer and groundwater springs are not known to be used for domestic water supplies. However, the till aquifer provides recharge for the bedrock aquifers. At all three sites, water levels in shallow bedrock testholes were at higher elevations than in deep testholes indicating a downward gradient associated with recharge conditions. The yield from the testholes was found to be dependant on the density of the fractures intersected.

Agricultural use of the groundwater resource is limited in the immediate area of the proposed sites. Detailed evaluations of water consumption have not been undertaken due to the distances to users from the sites. However, water for livestock consumption is expected to be the main use and groundwater sources similar to those used for domestic purposes would provide the supply. Water for industrial purposes formerly included a deep well at the CN Humpyard, but municipal water is now used.

The City of Moncton currently uses surface reservoirs for the municipal water supply and there are no producing municipal wells near the proposed sites. The City is considering groundwater wells as an emergency back-up supply for the reservoir system. Although the geological structures identified in the present study have potential for high yield groundwater wells, the distance to the existing municipal distribution system, the lack of development in the vicinity of the proposed landfills, and the average low yield of the aquifers giving rise to the uncertainty that a well with a yield that would make its construction practical (> 350 gpm) suggest a low probability that municipal wells would be developed in these areas in the near future.

The municipal distribution system currently services the Edinburg Drive/English Street areas to the east of the Delong Drive/Berry Mills Road sites. To the south of the sites, the distribution system extends along the Salisbury Road to the Llangollen Road.

4.2.1 IMPACTS AND MITIGATION

The design for the proposed waste management facility includes a leachate containment system which would minimize the risk for impact on the groundwater resource. However, impacts on the groundwater resource could occur if the containment system fails. Heavy metals, gases, organic compounds, and inorganic compounds (such as calcium, chlorides, and sodium) could be released into the groundwater. These potential impacts will be mitigated by the use of design and construction techniques which minimize the risk of leachate migration. A well designed and conscientiously operated monitoring program would provide a secondary system to give an early indication of leachate migration and enable remedial action to be taken in a timely manner to correct the situation.

Several factors would influence the direction and rate of any contaminant movement. These factors include the groundwater flow direction, the depth to water, the hydraulic gradient and groundwater velocity, the presence of geological structures and the permeability and porosity associated with such structures, the permeability, thickness, compaction, and compositional variation of the till, the permeability associated with the till/bedrock interface and/or the weathered upper layer of bedrock, and a variety of related factors.

If the contaminant reached the water table, migration would also depend on the nature of the leachate. Contaminants less dense than water, such as hydrocarbons, would remain on the top of the water. Some substances, such as solvents, are more dense than water and would continue downward until a confining layer was intersected. Many contaminants would be dissolved in the water and would follow the groundwater movement.

The groundwater at all sites was shown to have a downward gradient and water would move from the till aquifer to the shallow bedrock aquifer to deeper bedrock aquifers when confining layers are not present. Water movement in the bedrock would preferentially follow the zones of higher permeability possibly associated with the geological structures identified at the sites. The rate of movement would be governed by the permeability of the fracture zone and the hydraulic gradient.

It should be noted that the identified structures have not been completely defined and it is not possible to predict the actual path of an undetected long term chronic discharge with the information available at this time. It is suspected, but not proven, that they are related to bedrock fracturing. In the area of the Delong Drive Site and the Berry Mills Road Site, the high percentage of mudstone bedrock would suggest that the structures may be relatively impermeable due to the ability of the fine grained material to seal and heal fractures. The structures at the Route 126 Site are more apt to be relatively permeable as the strata consists of a lower content of fine grained (mudstone) rocks. Given the difficulties of defining the nature of these lineations, they should be viewed as possibly having relatively higher permeabilities and the landfill design planned accordingly.

After the final site selection has been made, a more detailed assessment of the on site lineations will be made to more fully evaluate their hydraulic characteristics. This assessment will target one or more structures and will involve core drilling and in-situ permeability testing. With this information plume modelling will be attempted to predict the potential path of a chronic discharge and assist in placement of monitoring wells.

Construction of a landfill cell directly over a major geological structure might result in a shorter path for contaminants to reac bedrock aquifers and should be avoided as much as possible. Th shorter, direct path would also reduce the effectiveness of the monitoring since contamination of the bedrock aquifers could occur before leachate collection could be initiated. Monitoring of the bedrock aquifer also would be constrained by the ability to define the spatial orientation (direction and dip) of the fracture systems. Avoidance of the fracture zone would not fully eliminate the risk associated with the structures since lateral migration could still occur. However, the pathway for migration would be lengthened and monitoring would have a greater opportunity to detect leachate. Increased thicknesses of compacted till or other suitable low permeability material over the geological structures would reduce the risk associated with them.

The testholes which have been constructed to date represent potential conduits for leachate migration into the bedrock aquifer. All testholes should be properly sealed prior to landfill construction, except the testholes to be used for monitoring purposes. To seal the testholes, bentonite or a bentonite grout would be used to fill the borehole from bottom to top. In addition, a bentonite seal would be placed around the near surface area of any remaining casing.

A hypothetical leachate leak scenario has been evaluated for the Berry Mills Road Site. The maximum possible leachate movement over various time periods was assessed using the field derived data, which are consistent with published information on the local formation. At the request of NBDOE the possible movement applying an order of magnitude safety factor to the derived hydraulic conductivity values was also assessed.

Groundwater velocities for the site were calculated to have a range of 0.96 to 2.60 meters per year for the shallow bedrock depths and 0.10 to 6.33 meters per year for the deeper depths. The hydraulic conductivities used to derive these velocities ranged from 1.0 to 63.3 meters per year. In light of the available information regarding the Salisbury Formation, these hydraulic conductivity values appear appropriate:

- A pump test of a well located less than one mile to the east indicated a hydraulic conductivity of 34.2 meters per year (Carr, 1968).

- Carr (1968) also found that there appears to be a low groundwater transmissibility zone within the Salisbury Formation which extends from the southwest to the northeast across the Moncton city area. This zone would include the Berry Mills Road Site and the Delong Drive Site.

- The Consultant's past experience within the City of Moncton limits has revealed that hydraulic conductivity values in the Salisbury Formation can be expected to range from 0.05 to 20.0 meters per year (unpublished "slug test" data).

Table 4-1 lists the groundwater velocities calculated for the shallow and deeper bedrock test zones. Due to the uncertainty of the assumed porosity value, which would be influenced by fracturing, a calculation was made using both a 7.5% and a 15% value. The groundwater velocities as shown on Table 4-a have been calculated using a derivation of Darcy's equation:

$$V = \frac{K(h)\ I}{N}$$

where V = velocity (m/year)
K(h) = hydraulic conductivity (m/year)
I = hydraulic gradient
N = porosity

At the request of the New Brunswick Department of the Environment, velocity calculations were also made using an order of magnitude increase of the maximum measured hydraulic conductivity.

The groundwater velocity is generally accepted as being the maximum flow rate that a contaminant can achieve. Therefore, the velocities calculated represent a maximum contamination movement velocity. The use of these velocities as being representative of the contaminant movement presents a considerable safety factor as the influence of dispersion, dilution, diffusion, chemical and biological degradation, and attenuation are not considered. These factors would not only delay the migration of contaminants, but would also result in the elimination of many of the contaminants prior to their transport from the site.

If a continuous undetected leachate leak to the groundwater were to occur, a point source plume would develop which would travel in the direction of groundwater flow. The plume would become elongated in the direction of groundwater movement and would increase in width away from the source based on the effects of dispersion and diffusion. The horizontal component of flow would be expected to be considerably greater than the vertical component due to the stratified nature of the bedrock. Therefore a majority of the plume would move as a spreading plane within the higher permeable zones.

TABLE 4-1

Groundwater Velocity
(meters/year)

	15% porosity			7.5% porosity		
	using minimum hydraulic conductivity	using maximum hydraulic conductivity	using maximum hydraulic conductivity x 10	using minimum hydraulic conductivity	using maximum hydraulic conductivity	using maximum hydraulic conductivity x 10
shallow depth (max. - 8.0 m)	0.96	2.61	26.1	1.92	5.23	52.3
deeper depth (max. - 46 m)	0.1	6.33	63.3	0.2	12.66	126.6

Note:

Hydraulic conductivities measured - shallow - minimum 7.2 m/yr.
- maximum 19.6 m/yr.
deeper - minimum 1.0 m/yr.
- maximum 63.3 m/yr.

Due to the different chemical characteristics of the various leachate components, such as solubility, the plume would become chemically segregated with time and movement. Some components would migrate at a faster rate than others.

The amount and rate of transfer of the contaminants through the bedrock would depend on the groundwater velocity and the attenuation in the subsurface caused mainly by adsorption, and on the chemical and biological degradation time of the substance. The contaminant concentrations of the plume would therefore decrease away from the source at varying rates depending on the constituent.

The active landfill cells at the Berry Mills Road Site will be located more than 800 meters from the southern boundary of the property (direction of groundwater flow) and 3000 meters from the nearest point of the Petitcodiac River (ultimate groundwater flow destination). The groundwater flow direction is generally to the south from the site.

Based on the groundwater flow velocities obtained by using varying values for porosity and hydraulic conductivity, Table 4-2 indicates the time span which would be required for groundwater to move over the specified distances. Using the same information, Table 4-3 was developed which indicates the number of meters over which the groundwater would migrate given various time spans.

It can be seen from Tables 4-2 and 4-3 that given the worst case scenario based on the maximum measured hydraulic conductivity, it would take over 60 years for a leachate plume to move from a landfill cell to the property boundary. A properly designed groundwater monitoring system would detect any leachate prior to this event and remedial activities would be undertaken to not only stop the leak but clean up the contamination. Assuming a worst case scenario of a permeable fracture deflecting groundwater flow from the general southerly direction, it is assumed that the flow would be directed more south-westerly due to the southwest-northeast geological structural trend. Exhibit 4-4 shows a hypothetical leachate leak in the area of Test hole 2. If the groundwater flow was controlled by a preferential flow path caused by fracturing associated with this potential structure, the contaminant plume would be directed along the structure. The location of the plume front at various time spans is plotted (assumes that the leachate contamination migrates at the same rate as the groundwater velocity). The plotted data assumes a 7.5% porosity and uses the maximum measured hydraulic conductivity value as well as the maximum measured hydraulic conductivity increased by one order of magnitude.

TABLE 4-2

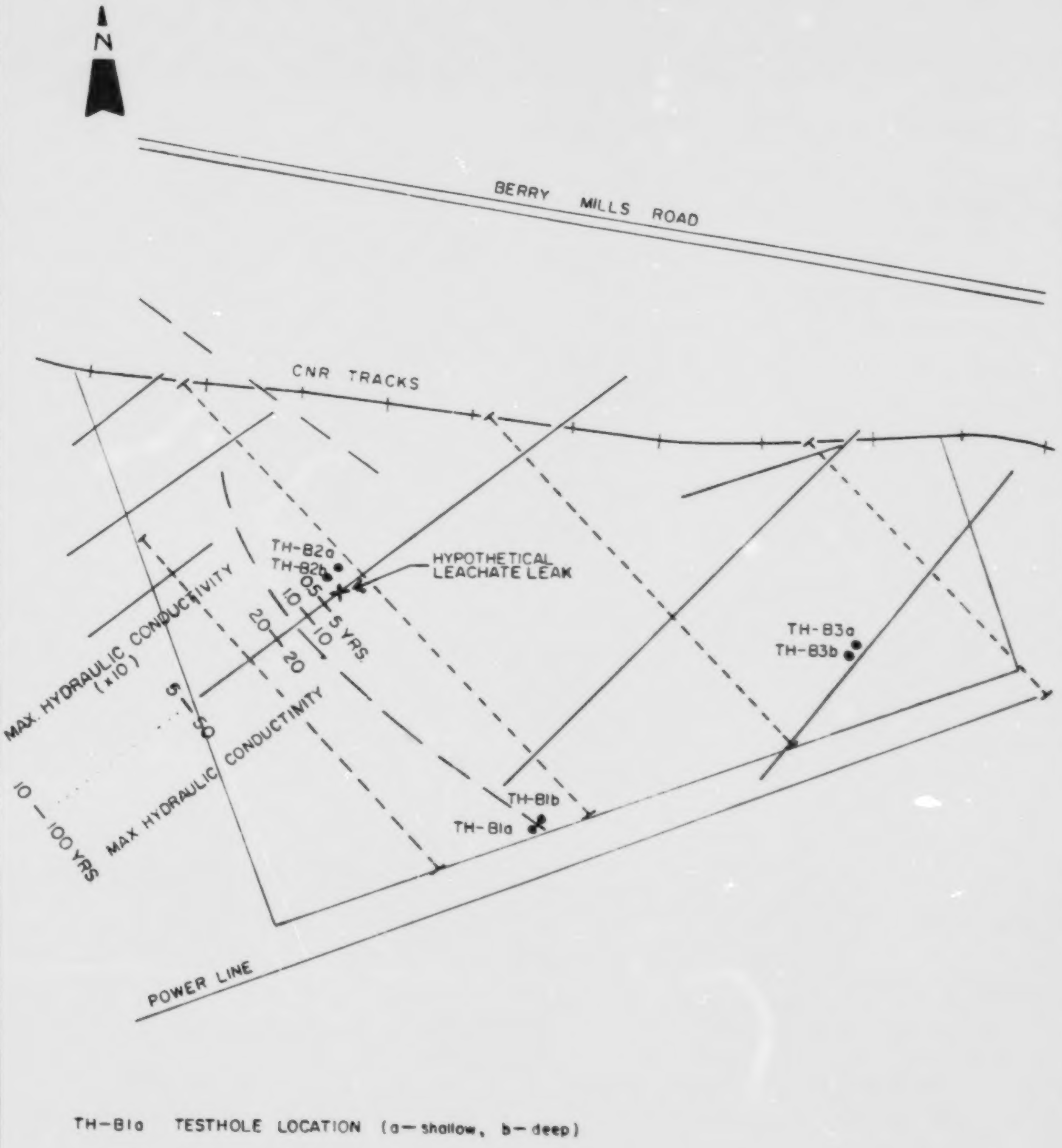
Groundwater Flow Time Span per Specified Distance

Depth of Groundwater Flow System	Porosity	Hydraulic Conductivity	Time (in years) required for groundwater to travel	
			distance landfill cell to property boundary (800 m)	distance landfill cell to Petitcodiac River (3000 m)
Shallow	15%	min. measured	833	3125
		max. measured	307	1149
		max. x 10	30.7	115
	7.5%	min. measured	417	1563
		max. measured	153	574
		max. x 10	15.3	57
Deeper	15%	min. measured	8000	30,000
		max. measured	126	474
		max. x 10	12.6	47
	7.5%	min. measured	4000	15,000
		max. measured	63.2	237
		max. x 10	6.3	24

TABLE 4-3

Groundwater Flow Distance per Specified Time Span

Depth of Groundwater Flow	Porosity	Hydraulic Conductivity	Distance of Groundwater Flow (meters) over:					
			1 yr.	5 yrs.	10 yrs.	20 yrs.	50 yrs.	100 yrs.
Shallow	15%	min. measured	1.0	5	10	19	48	96
		max. measured	2.6	13	26	52	131	261
		max. x 10	26	130	261	522	1305	2610
	7.5%	min. measured	2	10	19	38	96	192
		max. measured	5.2	26	52	105	262	523
		max. x 10	52	262	523	1046	2615	5230
Deeper	15%	min. measured	0.1	0.5	1	2	5	10
		max. measured	6.3	32	63	127	317	633
		max. x 10	63	317	633	1266	3165	6330
	7.5%	min. measured	0.2	1.0	2	4	10	20
		max. measured	12.7	63	127	253	633	1266
		max. x 10	127	633	1266	2532	6330	12660


N
BERRY MILLS ROAD
CNR TRACKS
TH-82a
TH-82b
HYPOTHETICAL LEACHATE LEAK
.05
1.0
5 YRS.
10
10
20
20
5 — 50
MAX. HYDRAULIC CONDUCTIVITY (x10)
MAX HYDRAULIC CONDUCTIVITY
10 — 100 YRS
TH-83a
TH-83b
TH-81b
TH-81a
POWER LINE

TH-81a TESTHOLE LOCATION (a—shallow, b—deep)

PRIMARY STRUCTURE

SECONDARY STRUCTURE

GEOPHYSICAL SURVEY LINE

EXHIBIT 4-4

BERRY MILLS ROAD SITE
HYPOTHETICAL LEACHATE LEAK PLUME
FRONT LOCATION OVER TIME
SCALE 1:20,000
0 500m

The planned monitoring system will be designed to monitor all possible leachate pathways at varying distances from the landfill cells. These monitoring systems will test major fracture zones, if any are identified during the final site studies. The location of the monitoring wells will ensure that ample time will be available for remedial action should contamination be detected. After the initial monitoring system is in place, additional monitoring wells may be installed as necessary. Any leachate plumes would be identified and characterized prior to reaching the site boundary.

The use of a well designed monitoring program to detect leachate migration would permit remediation measures to be undertaken in sufficient time to prevent extensive spread of contaminants, and certainly before migration could occur offsite. In this case, compensation plans would not be necessary as the remediation program is put into effect. However, if leachate from the facility were to impact on adjacent private wells, the Commission will establish a compensation plan to provide the affected party(s) with an alternate supply of water. The groundwater monitoring system will be designed according to the conditions of the final site selected, but should monitor all potential leachate migration pathways. This would include the various subsurface formations (surficial glacial till, shallow bedrock, deep bedrock) and also the identified areas of preferential flow. Monitoring wells will be strategically placed between the cells and the identified structures which may have relatively high permeabilities.

Should a contaminant be detected, an immediate assessment to define the scope of the problem would be conducted and a remediation operation put in place. Various treatment and remedial options are available and would be designed as required to deal with a particular contamination event. A possible remediation effort could involve the installation of a leachate collection trench to contain the contaminant and direct it to the leachate treatment system. Depending on the situation, additional monitoring wells may be installed to further define the extent of the contamination and a hydrogeological risk assessment study conducted to provide additional information for remediation planning.

If in fact it is found that the movement and distribution of a leachate plume is influenced by a fracture system of relatively higher permeability, this characteristic can be considered beneficial in regards to the recapturing of the leachate. Boreholes can be utilized to pump the leachate contaminated from the fracture system with relative ease. Such a remediation system is hydraulically more controllable, allowing the recovery of the leachate from a defined and limited pathway.

The discussions of the individual sites in the subsections which follow outline the geological and hydrogeological factors of pertinence to each site. In a regional perspective, the three sites exhibit characteristics which are typical of the geological environments present in the area. The factors identified for each site are discussed within the context of landfill design considerations rather than constraints to development.

Delong Drive Site

The groundwater flow at the Delong Drive site was found to be in a generally southwesterly direction. A southeasterly to easterly flow is inferred for the eastern side of the site and the monitoring program should be designed to provide confirmation of this. The residences nearest the site are situated about 1.1 km north of the site (Horseman Road-Ryan Road area) but at these locations impacts would not be expected due to the groundwater flow direction. The CN Humpyard is located to the south of the site and residences are also located to the south along Salisbury Road. Municipal water is available along the Salisbury Road (to the Llangollen Road) and at the CN Humpyard.

A breach in the containment system would release leachate into the till layer underlying the cell. Investigations in the Site Selection Phase showed the till to have a relatively low permeability (hydraulic conductivity of 1.4×10^{-8} to 4.5×10^{-9} metres per second in laboratory tests). On this basis, leachate would be expected to move slowly through the till. However, compositional variation within the till, interfaces such as that between the till and bedrock, and the zone of weathered bedrock may allow preferential migration of contaminant. The initial movement of leachate within the upper unsaturated strata would be strongly controlled by gravity flow and by perched water movement. The identified perched water zones were found above the glacial till and at the glacial till - bedrock intersurface. These zones would tend to direct the leachate laterally and at a rate which would be dependent on the influence of rainfall infiltration and leachate quantity. The direction of this perched movement would reflect the topographic slope within the local area and is generally in a southerly direction although local variations do occur.

Upon reaching the groundwater the leachate contamination would be expected to follow the groundwater flow. The bedrock was found to be fine-grained sedimentary rocks which typically would also have low permeability except possibly where fracture zones are present. The geological structures which have been identified in the bedrock are believed to be fracture zones and represent potential conduits that may allow preferential migration of contaminant. Movement along these zones, both vertically and in the general direction of groundwater flow would be expected. The design of the landfill should provide setbacks in the order of 50 to 100m from the up-gradient side of the identified geological structures and monitoring wells should be constructed between cells and structures (down-gradient of the cell and up-gradient of the structure). This approach minimizes the risk for release of contaminants into the bedrock aquifer. The ultimate fate of any contaminated groundwater, if it were able to follow the complete groundwater flow path, would be groundwater discharge to the Petitcodiac River.

Berry Mills Road Site

The groundwater flow at the Berry Mills Road Site is in a south to south-southwest direction. Groundwater supplies for residences to the north of the site (over 2 km distance) would not be expected to be impacted by the proposed development. Residences to the south along the Salisbury Road are also a considerable distance from the site. Municipal water is available as far west as the Llangollen Road.

A breach in the containment system would release leachate into the till layer underlying the cell. The Site Selection Report estimated (based on samples from the Delong Drive Site) the till to have a relatively low permeability (hydraulic conductivity of 1.4 x 10^{-8} to 4.5 x 10^{-9} metres per second). On this basis, leachate would be expected to move slowly through the till. However, compositional variation within the till, interfaces such as that between the till and bedrock, and the zone of weathered bedrock could allow preferential migration of contaminant. As with the Delong Drive Site, the initial movement of leachate due to a containment system breach would be within the unsaturated strata and be controlled by gravity flow and by perched water movement. The perched zones were found above the glacial till and at the glacial till-bedrock interface. These zones would direct the leachate laterally at a rate dependent on the influence of rainfall infiltration and leachate quantity. The movement of the perched water flow would reflect the local topographic slopes and at this site be generally in a southerly direction.

Upon reaching the groundwater the contaminant migration would be expected to follow the groundwater flow and move to the south. The bedrock was found to be fine-grained sedimentary rocks which typically would also have low permeability except possibly where fracture zones are present. The geological structures which have been identified in the bedrock are believed to be fracture zones and represent potential conduits that would allow preferential migration of contaminant. Movement along these zones, both vertically and in the general direction of groundwater flow, would be expected. A northeasterly trending geological structure which is thought to be of regional significance, i.e. is laterally continuous for a distance of several kilometres, crosses the southern portion of the site. The potential for contaminant migration along this fracture should be considered high. The monitoring program should be carefully designed to ensure sufficient coverage so that a leachate plume could not reach the structure prior to detection. Development should avoid this feature and the other indicated structures and their lateral extensions. A setback (on the up-gradient side of the structure) in the order of 50 to 100 m is recommended. Monitoring wells should be constructed between cells and identified geological structures (down-gradient of the cell and up-gradient of the structure). This approach minimizes the risk for release of contaminants into the bedrock aquifer. The ultimate fate of any contaminated groundwater, if it were able to follow the complete groundwater flow path, would be groundwater discharge to the Petitcodiac River.

Route 126 Site

The groundwater flow at the Route 126 site was found to be in a northwesterly direction. Groundwater supplies for residences on Indian Mountain Road to the south of the site would not be expected to be impacted by the proposed development. The Cocagne River is situated about 1 km north of the site.

A breach in the contaminant system would release leachate into the till layer underlying the cell. Field testing in the Site Selection Phase indicated the till to have a hydraulic conductivity of 10^{-8} to 10^{-9} metres per second. On this basis, leachate would be expected to move slowly through the till. However, compositional variation within the till, interfaces such as that between the till and bedrock, and the zone of weathered bedrock could allow preferential migration of contaminant.

The initial movement of leachate contamination would be within the unsaturated strata and be strongly controlled by gravity flow and perched water movement. These perched zones are most likely to be found above the dense glacial till at the glacial till-bedrock interface and would direct the contaminant laterally at a rate dependent on the influence of rainfall infiltration and leachate quantity. The direction of this movement would be to the northwest reflecting the topographic slope within the local area.

Upon reaching the groundwater the leachate contamination would be expected to follow the groundwater flow and move in a northeasterly direction. The bedrock at the site consisted of sedimentary rocks including sandstone and siltstone. The site is in a geologically complex area which has undergone considerable faulting and fracturing. Geological structures have been identified in the bedrock which are believed to represent fracture zones and are potential conduits that would allow preferential migration of contaminant. Movement along these zones would be expected. Since the major structures are sub-perpendicular to the groundwater flow direction, the vertical component of the movement would tend to dominate. Higher hydraulic conductivities were noted in the shallow bedrock aquifer. Development of cells should avoid the identified structures and their lateral extensions. Monitoring wells should be constructed between all cells and identified geological structures (down-gradient of the cell and up-gradient of the structure). Evaluation of potential off-site structures should be undertaken. A setback of 50 to 100m (on the up-gradient side) from identified geological structures should be maintained to minimize the risk of contaminants entering the bedrock aquifer. The ultimate fate of any contaminated groundwater, if it were able to follow the complete groundwater flow path, would be groundwater discharge to the Cocagne River.

4.3 Surface Watercourses

This section discusses the possible impacts of suspended sediments and leachate on surface watercourses, as well as the appropriate mitigation measures to be taken.

4.3.1 IMPACTS

Impacts to fish and wildlife resource are summarized for each site and according to project phase, i.e. Construction, Operation and closure (post-closure). The matrix elements for these resources are described in Table 4-4.

4.3.1.1 Suspended Sediments

Activities having the potential for releasing sediments to Michael's Creek, Jonathan Creek (Delong Drive Site), Jonathan Creek, Somers Creek (Berry Mills Road Site), Shaw Brook and the Cocagne River (Route 126 Site) include access road building, clearing and grubbing, excavation of cover material, drainage system construction and disposal of waste. As control facilities for sediment control will be provided for all activities, only accidental releases will be of concern.

As there is a high degree of industrial development adjacent to Michael's Creek, any accidental releases may add more stress to the watercourse. However, the impact of accidental releases in the "polluted" receiving stream is less significant.

Should there be a failure of erosion control features during access road construction, a high sediment load may arise in Jonathan Creek and Somers Creek respectively. However, this accidental high sediment load would cease once road construction is completed.

The unnamed branch of Somers Creek that crosses the southwestern corner of the Berry Mills Road site will not be influenced by access road building. Since it is located between the constraint line and the property line, activities such as clearing and

TABLE 4-4

Impacts to Fish and Wildlife Resources

SELECT IMPACT ISSUES	CONSTRUCTION PHASE ACTIVITIES				
	Road Construction	Clearing & Grubbing	Drainage Works	Dev't of Borrow Area	Buildings & Services
A. Delong Drive Site,					
Fish Habitat	0	0	0	0	0
Wildlife	0	1	1	1	0
B. Berry Mills Road Site,					
Fish Habitat	0	1	2	1	0
Wildlife	1	0	1	1	0
C. Route 126 Site,					
Fish Habitat	0	0	2	1	0
Wildlife	1	1	1	1	0
	Operations and Closure/Post-Closure Phases				
	Trucking of Waste	Site Drainage	Exc. of Cover	Disposal of Waste	Closure & Post-Closure
A. Delong Drive Site,					
Fish Habitat	0	0	0	0	0
Wildlife	0	0	0	0	0
B. Berry Mills Road Site,					
Fish Habitat	0	2	0	2	1
Wildlife	0	0	0	0	0
C. Route 126 Site,					
Fish Habitat	0	2	0	2	1
Wildlife	0	0	0	0	0

no impact = 0; impact without mitigation steps = 1; some impact expected with steps taken to reduce the impact = 2 grubbing, cover material removal, and drainage system completion will not contribute to an increase in the sediment load.

If the Route 126 Site is chosen, watercourse alterations will be meticulously prepared regarding improvements on both the Melville Road and the Garland Road. Sediment losses into the two unnamed branches of the Cocagne River will receive the most attention. If a significant fraction of suspended sediments are deposited downstream on the mainstem of the Cocagne River, water quality may be altered, in turn altering salmonoid spawning.

In the Petitcodiac River above the causeway, the greatest proportion of the variation in sediment loading is likely accounted for by timing of the opening and closing of the causeway control gates. Increased sediment loads into the Petitcodiac River from accidental discharge at the landfill site via Michael's Creek or Somers Creek would not cause serious concerns. This is because the volume of sediment discharged from Michael's Creek or Somers Creek would be very small compared to sediment loads already in the Petitcodiac River.

4.3.1.2 Leachate

No direct discharge of leachate will be allowed to any of the surface watercourses. All leachate will be pretreated and conveyed to the Greater Moncton Sewage Commission wastewater treatment plant. However, accidental discharges could affect nearby streams.

Michael's Creek (the Delong Drive Site) is a very minor concern. Present residential and industrial developments already contribute untreated effluents and sediment deposits to this stream. This watercourse would be the least affected by accidental effluent releases from any sedimentation and leachate collection pond.

Topography of the Delong Drive and Berry Mills Road Sites dictates the positioning of ponds to the southern portion of the sites. Jonathan Creek will therefore not be affected by accidental discharge of leachate. However, fish habitat below the beaver dam on the unnamed north branch of Somers Creek may be influenced. Due to the fact that is is gradually drying up, the marsh behind the beaver dam will only act as a natural filter (for nutrient inputs) for a short period of time (i.e. probably less than five years in this specific instance).

Topography of the Route 126 Site dictates the positioning of ponds to the northern portion of the site. Although the Cocagne River will be affected, Shaw Brook will not be affected by accidental discharge of leachate.

The major difficulty in assessing the impact of accidental leachate releases on the mainstem of the Petitcodiac River is one of volume differences between it and either Michael's Creek or Somers Creek. Volume here refers not only to the discharge volumes of these tributaries and the main river prior to the potential addition of sanitary landfill effluent, but also the volume of material that has already entered the mainstem of the river from outfalls used in the past and the old City Dump. Leachate contamination monitoring on the main river may be confounded by substances deposited in the sediments in the past. Impacts can most practically be evaluated in terms of their influence on the small tributaries adjacent to the site and not the Petitcodiac River itself (Hal Bailey, pers. comm., 1991).

In order to illustrate the possible impacts from an accidental leachate release into Michael's Creek, Somers Creek, the Cocagne River, and the Petitcodiac River, it is necessary to consider the daily flow rates of these watercourses. Flow data are only available for the Petitcodiac River. The flow rates from other watercourses were approximated by prorating from the Water Survey of Canada gauging station 01BU004 on Palmers Creek, which is near Dorchester, N.B. The information is presented in Table 4-5.

As the proposed leachate treatment lagoon has a total storage volume of 1600 m^3 it can be assumed that an accidental discharge of the entire lagoon contents in a short period of time could certainly impact Michael's Creek, Somers Creek and possibly the Cocagne River during their low flow periods. During high flows the impacts would be reduced to minimal. As the main stem of the Cocagne is over 1 kilometer from the site, the impacts will be lessened and dilution would increase in all streams due to the influence of water stored in ponds on the streams.

Worst Case Scenario - Catastrophic Discharge

As indicated above, a worst case scenario would occur if the entire volume of the leachate pond (1600 m^3) would enter Michael's Creek, Somers Creek or the Cocagne River over a period of one day during the summer low flow period. Assumed leachate characteristics for leachate from recent wastes (e.g. first 5 years of operation) and leachate from aged wastes (e.g. 25 years of operation) are listed in Table 3-2. Biodegradation and other processes in the leachate collection pond will influence the concentration of leachate parameters. Therefore, strengths of leachate parameters assumed for modelling purposes are listed in Table 4-6.

TABLE 4-5

Extreme Daily Flows in Watercourses Adjacent the Delong Drive, Berry Mills Road and Route 126 Sites

Watercourses	Drainage Area (km^2)	Extreme Daily Flows	
		Minimum* (m^3/d)	Maximum** (m^3/d)
Palmers Creek	34.2	1210	24.1×10^5
Michael's Creek	9.8	350^E	$6.9 \times 10^{5\,E}$
Somers Creek	14.7	520^E	$10.4 \times 10^{5\,E}$
Cocagne River	70.0	2480^E	$49.3 \times 10^{5\,E}$
Petitcodiac River (near causeway)	1280	28840^E	$594 \times 10^{5\,E}$
Petitcodiac River (near Petitcodiac)	391.0	8810	181.4×10^5

* Lowest flow ever measured over the life of the hydrometric station.

** Highest flow ever measured over the life of the hydrometric station.

E = estimated

References:

- Flow Duration Curves for Hydrometric Stations in New Brunswick. 1984. Water Resources Branch, NBDOE.
- Moncton Planning Region Water Resources Review. 1984. Report I - 8402. Water Resources Branch. NBDOE.

TABLE 4-6

Leachate Parameter Concentrations Assumed
for Computational Purposes in Worst Case Scenario

Parameter	Untreated Concentration mg/l	Concentration in Leachate Collection Pond* mg/l
BOD	11900	6000
Phosphate	0.73	0.4
Nitrate-Nitrite	3	1
Cu	0.12	0.06
Fe	540	250
Pb	1.4	0.5
Zn	21.5	10

* Biodegradation and settling considerations based on past experience (e.g. Nepisiguit-Chaleur Regional Landfill, Halifax Regional 101 Landfill, etc.)

The scenario considered as an example would involve a breach of the leachate treatment system with complete loss of contents over a one day period. It has also been assumed that the leachate would mix fully with receiving water at the point of discharge.

Due to relatively small quantity of water flow during low flow periods at this time of year, especially in Michael's Creek and Somers Creek, a large volume spill would be detrimental to water quality. However, upon reaching the Petitcodiac River, the spill would be effectively diluted by a factor of approximately 20 to 1 based on extreme minimum daily flows. The dilution factor would be much greater than this because of the comparatively large volume of water in the lake above the causeway. This would therefore result in minimal effects on the Petitcodiac River. Since the mainstem of the Cocagne River is located over one kilometer away from the site, this would tend to lessen the impacts on it.

In order to demonstrate the effect of leachate contamination on these watercourses, parameters of potential concern have been selected and their effects predicted. Only dilution effects have been considered in calculations of parameter concentrations in the receiving environment. Stream flows used in the calculations are listed in Table 4-5, while background concentrations of selected parameters in these watercourses are given in Table 2-11. A summary of the effects is presented in Table 4-7.

For this scenario, as shown in Table 4-7, the predicted concentrations of all parameters, except for phosphate, would exceed guideline values in all watercourses. As well, all selected metals, except for lead, would also exceed the lethal levels for fish.

Long-Term Steady Discharge

Although the long-term release of untreated leachate would not be as devastating as the worst case scenario previously described, it would nonetheless be detrimental to the receiving environment.

For computational purposes, a maximum average annual leachate flow of 36 m^3/d (see Section 3.3.6.3) and leachate concentrations given in Table 4-6 (column one) were assumed, and based on 30 day flow duration curves (Flow Duration Curves for Hydrometric Stations in New Brunswick, 1984), summer low flows in the watercourse were estimated at 4 times the minimum flows shown in Table 4-5. This would result in similar effects to those for a spill (worst case scenario). However, the magnitude of impact on the various water quality parameters would be much less. This is illustrated in Table 4-8.

For this case, predicted concentrations of BOD and selected metals exceed guideline values for the protection of aquatic life.

Effluent from the leachate pre-treatment system will have no discernable effect on the GMSC sewage treatment plant. The effluent will meet discharge limits to the sewer system as imposed by the City of Moncton and the GMSC. As noted in Section 3.3.6.3, the GMSC plant has a very large capacity in both volume and BOD loadings as compared to the expected effluent from the leachate pre-treatment system. The pre-treatment system could be modified to improve metals removal by installation of a lime addition system. The pre-treatment ponds will eventually require removal of sludge. This would be disposed of in the landfill area.

TABLE 4-7

Potential Effects of Leachate Spill on Selected Water Quality Parameters During the Extreme Minimum Daily Flow Period

Location	Volume	Parameter Concentrations (mg/l)						
		BOD	Phosphate	Nitrate-Nitrite	Cu	Fe	Pb	Zn
Leachate	1600 m^3	6000	0.4	1.0	0.06	250	0.5	10
Michael's Creek	350 m^3/d	4923	0.3	0.9	0.05	205	0.4	8.2
Somers Creek	520 m^3/d	4528	0.3	0.8	0.05	189	0.4	7.5
Cocagne River	2480 m^3/d	2354	0.2	0.4	0.03	99	0.2	3.9
Guidelines for Aquatic Life(1)		n/a	< 1.0	n/a	0.002	0.3	0.001	0.03
Safe Concentration for Continuous Exposure of Fish					0.009(2)	7.5(3)	0.058(4)	0.036(5)
Lethal Level					0.025(6)	> 12.5(3)	4.82(7)	0.093(8)

(1) CCREM Guidelines for Freshwater Aquatic Life. 1987.

(2) brook trout, Cu^{++}; McKim and Benoit, 1971.

(3) brook trout, Sykora et al., 1972.

(4) brook trout, total lead; Holcombe et al., 1976.

(5) rainbow trout; Goettl et al., 1976.

(6) Atlantic salmon, incipient lethal level; Carson and Carson, 1972.

(7) brook trout, mean acute toxicity; U.S. EPA, 1985.

(8) rainbow trout, 96-h LC_{50}; Chapman, 1978.

TABLE 4-8

Potential Effects of Long-Term Leachate Discharge on Selected Water Quality Parameters During the Summer Low Flow Period*

Location	Volume (m^3/d)	Parameter Concentrations (mg/l)						
		BOD	Phosphate	Nitrate-Nitrite	Cu	Fe	Pb	Zn
Leachate	36	11900	0.73	3.0	0.12	540	1.4	21.5
Michael's Creek	1400	300	0.12	0.4	0.01	14.3	0.04	0.6
Somers Creek	2080	204	0.06	0.07	0.01	9.7	0.02	0.4
Cocagne River	9920	45	0.05	0.03	0.02	3.0	0.006	0.09
Guidelines for Aquatic Life(1)		n/a	< 1.0	n/a	0.002	0.3	0.001	0.03
Safe Concentration for Continuous Exposure of Fish					0.009(2)	7.5(3)	0.058(4)	0.036(5)
Lethal Level					0.025(6)	> 12.5(3)	4.82(7)	0.093(8)

(1) CCREM Guidelines for Freshwater Aquatic Life. 1987.

(2) brook trout, Cu^{++}; McKim and Benoit, 1971.

(3) brook trout, Sykora et al., 1972.

(4) brook trout, total lead; Holcombe et al., 1976.

(5) rainbow trout; Goettl et al., 1976.

(6) Atlantic salmon, incipient lethal level; Carson and Carson, 1972.

(7) brook trout, mean acute toxicity; U.S. EPA, 1985.

(8) rainbow trout, 96-h LC_{50}; Chapman, 1978.

* Summer low flows 4 times extreme minimum flows

4.3.2 MITIGATION

Mitigation goes far beyond damage control. Its primary goal is an expression of a commitment to implementing environmentally responsible construction and training practices that meet or surpass regulations and stipulations. Adhering to current laws is only the beginning of the process. The explicit sets of objectives, policies and technical procedures are established before there is a net loss of habitat.

The keys to the success of the mitigation program will be the use of approved or standard testing methodologies for monitoring water quality and biological resources at select stations (a minimum of 3) for the watercourses adjacent to the chosen site, the prompt release of clear statements on facility operation, and a commitment to periodic review (e.g. 2/year) of testing methodologies.

4.3.2.1 Suspended Sediments

In order to reduce the probability of accidental releases, a number of steps will be taken.

1. Sedimentation holding ponds will be constructed before any other construction takes place.
2. Ditches and ponds will be cleaned out and maintained on a regular basis.
3. Erosion preventive measures will be maintained for all ditches and berms.
4. Sampling will be undertaken to ensure that effluent standards are met.
5. Sediment control measures will be part of the training for all operators.

4.3.2.2 Leachate

The leachate containment and collection system and the on-site pretreatment system described in Section 3 will be provided at the selected site. No direct discharge of leachate will be permitted to any of the surface watercourses. Recycling of leachate into the landfill may be undertaken but is not necessary for quality control given the treatment system proposed.

Regardless of which site is selected, leachate will be aerobically pre-treated, on-site, to reduce BOD. The pretreatment system will be operational before the second year of landfill operation. A leachate collection pond will be sufficient for the first months of operation.

Should the Delong Drive or Berry Mills Road Site be selected, the pretreated leachate will be piped via the sewer system, to the municipal wastewater treatment plant which will be operational in 1993. However, should the Route 126 Site be selected, the pretreated leachate will be trucked to the municipal wastewater treatment plant.

Sampling of leachate will be undertaken to monitor the quality of leachate and to ensure that the pretreatment system is operating properly. Federal and Provincial officials may decide to use surprise spot checks so on-site staff will be prepared at any time to provide a labelled aliquot to an inspector.

In order to address concerns related to an accidental discharge due to a structural type failure of the leachate treatment system, the following measures will also be taken:

- construction below grade as much as possible to remove the potential for berm failure;
- provision of an alarm system to indicate the pond is exceeding its normal operating level;
- provision of emergency discharge to the secondary containment pond (after pond has reached its maximum holding capacity).

As well, in order to mitigate the identified impacts due to an accidental discharge from the leachate treatment facility to nearby watercourses, a storage, or secondary containment pond, will be constructed between the treatment facility and the watercourse. Leachate accidentally released from the treatment facility would thus be contained and would be pumped back into the treatment facility or conveyed elsewhere for other treatment.

The training of all operators will include leachate control and management procedures. An experienced environmental technologist will be in charge of the leachate pretreatment system and monitoring systems. Reporting procedures will be emphasized. This particularly applies to accidental releases. Any accidental release will be immediately reported to the appropriate authorities and appropriate cleanup measures undertaken.

The construction of recycling and composting facilities and introduction of a household hazardous waste collection and storage operation will also mean significant improvements in leachate quality and its potential effects if accidental discharge to surface watercourses or the groundwater regime. Although these improvements have not been considered in the discussions on impacts, they should be considered a mitigative measure.

4.4 Wildlife Habitat

4.4.1 IMPACTS

Presently, black bears are a common nuisance animal at dump sites now operating in New Brunswick. However, with the phasing in of integrated waste management facilities in the province which include chain link fences around the site, deposition of ≈15 cm of till daily on the active cell, and the eventual deposition of a final cover layer mean that disturbances by bears at any selected site should be avoided. Daily cover of the active cell and proper operation of the facility including maintaining a small working face and regular cleanups will minimize any bird problem (i.e. seagulls) at the site.

Overall loss of wildlife habitat will be minimal if landfill site development proceeds at either of the Delong Drive or Berry Mills Road Sites since large tracts of softwood and intolerant hardwood forest have already been harvested.

The Delong Drive Site has the lowest habitat suitability rating and, from a terrestrial wildlife perspective, little impact on the forest habitat from this portion of the Westmorland County will result from site development.

Development on the Berry Mills Road Site will remove some fair habitat for big game mammals (e.g. deer) and, in the northwestern portion of the site, upland game birds will be displaced towards the west.

Impact on the Route 126 Site wildlife habitat will be moderate. Construction activities such as clearing, grubbing and the development of a borrow area will remove potential calving grounds for moose in the boggy area south of the Melville Road. Trucking activities during site operation may force moose to move either south towards Indian Mountain Road or to the Bailey Brook - New Scotland Area which is approximately 4 km to the north of the possible landfill site. Most of the area north of the clear cut section of the site is good habitat for deer; any deer will therefore be displaced. This movement will likely be east of the site and west of the site along the mainstem of the Cocagne River and its tributaries.

The following development scenarios are presented for the Route 126 Site.

Deer may use the central portion of the site as a wintering area; however, other forest stands outside the landfill site area are equally suitable. Moose will continue to frequent the Melville Road area. One or two places on an unnamed branch of the Cocagne

River may receive continued use as wintering areas. The "Mo" shown in Exhibit 2-19 will probably be a calving area and may receive increasing use.

If the site is subject to the construction activities associated with sanitary landfill development (see Exhibit 4-3), there will be a definite impact on wildlife for more than the active life of the site. Construction of the landfill site here would mean that at an additional 150 ha would be clear cut inside the constraint lines. The total site area of approximately 273 ha would not be available to wildlife or game species for 50 to 75 years.

The impact would be greatest on moose in the area. A good calving ground would be lost and two possible wintering areas would be abandoned. Relocation is expected to be in Bailey Brook headwaters. Deer would be displaced initially to the east and west of the site. As time progresses, the movement is expected to be northward to the Cocagne River. The habitat suitability for for other resident mammals and birds (eg. marten, ruffed grouse) would be reduced.

A numeric estimate of potential deer wintering habitat loss was alluded to in Section 2 of this report and is reported here. The summary is as follows:

Location	Gross Area	Crown Land Suitable For Deer Wintering Area Available Size
Route 126 Site	273 ha	80 ha
Block East of the Site	193 ha	115 ha
Block West of the Site	80 ha	65 ha
Between Northern Border of the Site and the Cocagne River	181 ha	90 ha
Remainder of Area between Cocagne River and Melville Road and between Route 126 and Victoria Road	approx. 2573 ha	200 ha
Totals	approx. 3300 ha	550 ha

Given a total area of 3300 ha for the larger region around the site, only about 17% (or 550 ha) contains suitable wintering area. If landfill site development occurs here this value will be lowered to approximately 14% without any shifts to the current site boundaries.

The operational and closure/post-closure phases of the landfill will have no impact on wildlife species, regardless of site location.

4.4.2 MITIGATION

Should the black bear become problematic near the selected site, a trapping and relocation program to be funded by the Solid Waste Commission may have to be undertaken. For other wildlife species, since FDS maps show that areas adjacent to the Berry Mills and Delong Drive Sites are of equivalent habitat suitability for the few individuals which will be displaced, no mitigation activities are proposed, other than maintaining the currently proposed constraint lines within the larger site borders (see Exhibit 2-18). No significant population declines in deer or moose populations in the Greater Moncton area are predicted if the sanitary landfill is located at either of these two sites. The carrying capacity of adjacent lands can accommodate a few more individuals.

Of the three potential sites, the Route 126 Site had the highest suitability rating for selected terrestrial wildlife species (deer, moose, marten, and forest birds other than ruffed grouse). If migration to tracts of land to the west, north and east of the site is not sufficient, the best mitigation plan is one of shifting the site border along the NE side of the site (see Exhibit 2-19). Given that 2 MWA's (in the SW corner of the site) and a DWA (in the NW corner of the site) have been tentatively identified from 1989 aerial transects, two site boundary shifts will be considered. Regarding the MWA's, the access road could be shifted north and parallel to its current position along a line closer to the current inner constraint line. As far as proximity to the NW corner DWA is concerned, shifting the site borders focuses on the eastern border. The strip size could be 1000 m long (i.e. N-S axis) and 500 m wide (i.e. towards the Victoria Road). The expansion of part of the eastern border would be offset by removing a strip of equal area from the NW corner of the current site plan for the landfill.

Further aerial transect results will be necessary to monitor the efficiency of site border changes. Although loss of wintering area availability will be minimized, some browse availability will be lost. This is a secondary consideration. The movement of deer throughout the remainder of a 3300 ha block should compensate for the loss of browse availability on the 273 ha site, since the majority of the prime wintering area in the ~3000 ha region is to the west, east and north of the site according to 1989 aerial transects (T. Pettigrew, per. comm., 1991).

The presence of a calving area for moose near the Melville Road is only implied here. The next set of aerial transects and ground observations in the Spring of 1992 are needed to confirm this. If construction proceeds at this site, it may be reasonable to assume moose will emmigrate. The likely destimation is the headwaters of Bailey Brook and southwest from there towards Route 126.

4.5 Aquatic Resources

Given the three general ecological management objectives of conserving habitat today through feedback between professional managers and a concerned general public, restoring spoiled areas, and the development of new habitats, the importance of a no net habitat loss is implied in the Federal Fisheries Act (Department of Fisheries and Oceans, 1987).

The general impact of suspended sediments and leachate from the proposed facility on biota involves two broad categories. These are shellfish and salmonoids.

Shellfish harvesting requires an absence of bacterial contamination [i.e. < 14 faecal coliforms/100 ml H_2O and < 10% of the samples with > 43/100 ml (N.B.D.O.E., 1984)]. No reports of acceptable counts in either the Cocagne Harbour or the Petitcodiac River - Shepody Bay system have been made recently (i.e. after 1984) or indeed since 1968 in regard to the Petitcodiac Basin Area. Current concerns for surface water quality in the Eastern Shore area are centered upon sewage treatment facilities for the Bouctouche Bay region. An additional outfall on the Cocagne River because of the placement of a sanitary landfill is more significant in terms of its impact on salmonoid populations above Notre-Dame than it is on shellfish populations in the estuary.

The analysis of impacts on aquatic biological resources and the implementation of mitigation measures because of the need for the solid waste management facility should focus on salmonoids. However, it first must be recognized that mitigation steps and monitoring procedures are not synonymous with enhancement. Although enhancement efforts do also require a great deal of careful planning; share in common with the EIA process the basic flow chart blocks of reconnaissance, assessment, planning and design, construction, and maintenance and monitoring; and enhancements efforts are subject to governmental review, they focus on one specific use of a stream. They are concerned with recreational and, in some instances, food fisheries. An EIA must consider many stakeholder groups and all potential uses of a particular resource or resources. Also, enhancement projects operate in an after-the-fact manner. That is to say, they exist to restore already impacted streams. The first principle of an EIA is "no net habitat loss" because of one project's development. Past projects on the watershed (e.g. causeway construction) are of secondary importance. In contrast to this, enhancement projects can be very much concerned with past developments on other projects separate from landfill site selection.

In summary, people primarily concerned with enhancing the salmon populations of the Petitcodiac River system emphasize the merits of permanently opening or altering somehow the operation of the causeway control gates. The quite separate function of this EIA is to ensure no net loss of habitat on either the Cocagne or Petitcodiac systems because of the location of an integrated waste management facility, a development established a generation after fichery management problems arose on the Petitcodiac River. The success of this EIA or "no further net loss of habitat project" paves the way for the more specific single issue enhancement projects, yet it must be remembered that no impacts made by the waste management facility and corresponding mitigating actions will be completely comprehensive from a Petitcodiac River fishery management perspective until the larger issue of causeway control gate status is resolved. Fisheries management recommendations are for the gates to remain open from April 1st to December 15th (J. Ritter, per. comm., 1991).

4.5.1 IMPACTS OF SUSPENDED SEDIMENT ON FISH AND BIOTA

Erosion and sedimentation are a major threat to our waterways. This is a possible, if not definite, impact issue at some locations throughout the Province. In Westmorland County, the Cocagne River is at least a medium priority salmon river.

The species of concern for all watercourses in Westmorland County and especially the Cocagne River are brook trout and the Atlantic salmon. They spawn in the fall from late September through early November, burying their eggs in gravel where they incubate during the winter. The eggs hatch in early spring and the fry subsist on nutrients stored in a sac on their abdomens. In May or early June they emerge from the gravel and start feeding on external nutrients. During the period that the fish are in the gravel, they are unable to avoid changes in water quality and are therefore extremely vulnerable. One condition that commonly kills incubating salmon or trout is the deposition of sediments on the gravel. Fine sediments can reduce the flow of water through the gravel and cause death of eggs or sac-fry through oxygen depletion (oxygen uptake by embryos is inhibited). Larger sand-size sediment can trap fry in the gravel where they die of starvation.

Should the Route 126 Site be chosen, it will be important to note the effects of accidental releases and sediments. During the (summer) construction period, effects of accidental releases might include the filling of pools and slack water areas on the edge of riffles that juvenile salmon and trout use as nursery areas.

Increased suspended sediment in streams during rainfall events also blocks sunlight entering the water column during daylight hours.

Suspended sediment particles may have metal ions bound to them chemically. Should sediment particles leaving the site experience a change in pH (e.g., a decrease in pH during the spring freshet), the metals could be released. The elevated concentration of metals could cause toxicity problems with stream biota.

Monitoring of all releases of surface waters will minimize problems associated with sediments, since releases within water quality standards will not pose problems.

4.5.2 IMPACTS OF LEACHATE ON FISH AND BIOTA

Depending on which site is chosen, three streams may be impacted by accidental effluent releases. These are Michael's Creek (Delong Drive Site), Somers Creek (Berry Mills Road Site), and the Cocagne River (Route 126 Site). Given the current level of residential and industrial development immediately adjacent to Michael's Creek, as well as the absence of aquatic life in Michael's Creek, this stream will be the least affected by accidental release of the treated effluent from the pond. Below the beaver dam on Somers Creek, some brook trout may be threatened if leachate release standards (see Section 3.3.6.1) are not met. The biggest impact issue here arises if the Route 126 Site is selected for development of the landfill. Stream sections on the main Cocagne River suitable for salmon parr, and holding pools for adult Atlantic Salmon are threatened if effluent standards are not met.

The parameters with the most likelihood to cause fish kills if untreated leachate is accidentally released are elevated dissolved zinc and ammonia levels (emphasis is placed on the latter substance). However, this should not occur since leachate will be treated to the required standard.

In addition to the above leachate parameters, in case of an accidental effluent release to a watercourse, BOD, heavy metals and organics concentrations will be closely monitored.

4.5.3 MITIGATION MEASURES

The following mitigation measures have been identified to address the impacts the potential release of suspended sediments and accidental discharge of leachate would have on fish and biota.

All Sites

Suspended Sediments Control

1. The first site work will be ditches and ponds to collect and contain sediments resulting from site construction. This will limit the opportunity for impacts on salmon and trout eggs or sac-fry which could result from accidental releases of sediments before sediment containment is in place.
2. Detailed site design and operating plans will incorporate erosion control and suspended solids containment features. This is of particular importance at the Route 126 Site.
3. In designing the settling ponds for sediment, provision will be made for the addition of equipment for sediment flocculation in the future. Also, ponds and ditches will be cleaned out and maintained on a regular basis.
4. Settling pond discharge will be monitored (4 times yearly).
5. Sediment control measures will be part of the training of all operators.

Leachate Control

1. The landfill will be designed to contain, collect, and treat leachate.
2. A leachate pre-treatment system, consisting of an aerated lagoon system, will be implemented to reduce BOD and suspended solids. The system will be on line prior to the second year of landfill operation. No discharge to watercourses is planned.
3. The pretreated leachate will be discharged to the municipal wastewater treatment plant. If the Delong Drive Site or Berry Mills Road Site is selected, the pretreated leachate will be piped to the plant via the sewer system. If the Route 126 Site is selected, the leachate will be trucked to the plant.
4. Regular sampling of leachate will be undertaken to ensure that the pretreatment system is operating properly. A program to monitor Michael's Creek, Somers Creek or Cocagne River tributaries north of the Garland Road for accidental leachate contamination will be undertaken.
5. Monitoring wells will be established to determine the potential of leachate contamination by movement through groundwaters.

Delong Drive and Berry Mills Road Sites

1. Should access from the Berry Mills Road be selected, road construction will require implementing bank stabilization measures on Jonathan Creek (e.g. log rip rap, rock rip rap, or gabions, and/or the planting of stream side vegetation).

2. The buffer strip between the ponds and the unnamed north branch of Somers Creek is now essentially clear cut (Exhibit 2-15). Establishing ground vegetation would assist in intercepting suspended sediments in pond effluent.

Route 126 Site

1. If a landfill facility is established at the Route 126 Site, bank stabilization devices will be incorporated north of the point where an improved Melville Road crosses the upper stretches of one of the Cocagne River tributaries.

2. A 60 m buffer strip will be left on the banks of the unnamed tributaries of the Cocagne River north of the Garland Road.

4.6 Socio-Economic System

The analysis of socio-economic impacts has been broken up into two components: (1) impacts due to site construction and operations; and (2) impacts due to traffic along haul routes.

4.6.1 SITE CONSTRUCTION AND OPERATIONS

4.6.1.1 Impacts and Mitigation Measures on Human Health and Safety

Health and Safety Risks

The worst case scenario of health and safety risks resulting from landfills is the potential for contaminated drinking water and explosions from methane build-up. Landfills can also cause worker health concerns from potential exposure to pathogens, infectious wastes or to hazardous wastes which could be present in the garbage.

Drinking water contaminated from a landfill typically results from leachate entering the ground water aquifers and migrating or seeping into a drinking water source. As the proposed sanitary landfill will be equipped with a proper leachate containment and collection system as well as a leachate treatment system, this risk will be considerably reduced.

Methane build-up in the proposed landfill will be dramatically reduced by the instalment of gas vents, therefore effectively eliminating the chance for explosions. Both the gas control and leachate control systems would be operated and monitored for many years after closure of the site.

Although combustibles such as old tires will be stored on the site, they will be properly piled in a cleared area and disposed of on a regular basis by shredding and sale of the product, therefore minimizing the chance for fires and the risk of forest fire if one did occur.

In order to reduce the risk of exposure to pathogenic organisms which may be found in garbage, employee training procedures will emphasize sanitation and use of proper clothing/equipment to reduce the potential for direct contact with municipal wastes.

Maintaining a small working face, daily covering of the waste deposited and regular site clean-ups will result in minimization of bird attraction. All sites are outside the recommended 8 km distance from airports and will not interefere with air traffic and flight paths.

Nuisance Conditions

Although health risks are minimal for the individuals residing close to the site and next to nil for residents of the greater region, the waste management facility may cause a number of nuisance effects. While these may not pose a direct risk to public health or to the environment, nuisance conditions can exacerbate other adverse features of the facility, may contribute to public concerns, and could lead to public health risks if not controlled.

Permanent Residents

As indicated in Section 2.1.2, there are no residences located less than one kilometre from all three potential sites. The nearest residence from the Delong Drive Site is located 1.1 km away, while the residences nearest to the Berry Mills Road Site and Route 126 Site are located 1.4 km and 1.6 km away, respectively. Site operations should have no adverse impacts on these households. Dust generated while moving earth and waste at the landfill will be controlled by limiting the size of the working face of the landfill and by watering roads when necessary. These households may, however, be adversely affected by noise generated by trucks carrying refuse to the site. This is addressed in Section 4.6.2.

Recreational Users

The potential impact of site operations for residents who pass by the potential sites or use them for recreational purposes is minimal. Both the Delong Drive Site and the Berry Mills Road Site are remote enough that they are not visible from residences or major thoroughfares within 4 km. However, part of the Route 126 Site is visible from some residences and certain areas along Indian Mountain Road. This will present no aesthetic concerns for passersby on Indian Mountain Road as long as berms are constructed to restrict this visibility.

At present, none of the three sites are being used; therefore, the use of the site as a waste management facility will not pose any great hardships.

4.6.1.2 Impacts and Mitigation Measures on Economic Structure

The development of one central waste management facility will result in the closure of 18 public and three private solid waste dumps within Westmorland and Albert Counties. This will concentrate the disposal of waste in the Moncton area. This will result in changes to waste disposal costs and a shift of employment.

The closure of the local dumps will result in the loss of site attendant jobs. Currently nine of the sites have full-time attendants and the rest have part-time, seasonal or no attendants. The loss of employment at the local sites will be partially off-set by new jobs at the regional facility. It is expected that the municipally employed attendants will be assigned to other duties upon closure of the local sites.

The collection and transportation of waste is more significant than disposal site operation in terms of employment. The establishment of one regional site will have minimal or no impact on the collection function and a modest impact on the transportation function. The collection function will be generally carried-out as it is being done now. However, for the communities outside of the Greater Moncton Area, it will be necessary to transport the waste a greater distance to the regional site. Communities such as Alma, Sackville, and Port Elgin will be faced with a significant haul distance. This will result in business and employment opportunities in the trucking business. Currently several private contractors are employed in rural areas doing waste collection. In some cases, they are using small trucks that would likely not be suitable for the longer haul distances to the proposed sites. Collection contracts will be tendered as is the current practice. All existing contractors will have the opportunity to provide a competitive service.

The range in haul distances would result in differences in transportation or linehaul costs for each community unless these costs are shared equally by all communities as as planned. Furthermore, commercial, institutional, and industrial businesses that are responsible for disposal of their own waste will face cost increases for those located outside of the Greater Moncton Area.

The development of a modern central disposal site presents the opportunity for new business opportunities related to salvage, recycling and other related activities.

4.6.1.3 Impacts and Mitigation Measures on Land Use

Delong Drive Site

As discussed in Section 2.6.2, there are not expected to be any negative impacts on the private properties adjacent to the site. Currently they are undeveloped. Future development of these lands is expected to be industrial in nature and the development of the site as a waste management facility is not seen as a deterrent. Future expansion of the industrial park would also not be constrained. For mitigation purposes, the proposed development plan for the waste management facility calls for buffer zones which will minimize any possible impacts on the adjacent land use activities.

The impact on adjacent land value and marketability are difficult to assess. Studies in other jurisdictions conclude there is no effect where proper setbacks and properly operated facilities are in place. In fact, land values and marketability for property adjacent to all three sites may increase because of the provision of access and services to the proposed facility.

No major impacts are expected on the recreational use of the site itself. There is no fishing on the site itself, nor in the adjacent areas (Michael's Creek, Jonathan Creek). Also, although some wildlife exists, no hunting is permitted, as the site is located inside city limits.

There are not expected to be any impacts on the existing utility infrastructure in the area. Possible plans by the CNR for the area will not be affected by the waste management facility.

The major area for potential impact relates to additional traffic and the possibility of roadside littering and illegal dumping, which are discussed in Section 4.6.2.

Berry Mills Road Site

As is the case for the Delong Drive Site, no negative impacts are expected on the private properties adjacent to the site. As well, the development of the site as a waste management facility is not seen as a deterrent to industrial development in the area nor to future expansion of the industrial park. Buffer zones surrounding the facility are planned for mitigative purposes.

Concerning recreational activities on or in the area of the site, fishing in Somers Creek and Jonathan Creek may possibly be impacted by leachate or sedimentation due to facility activities. However, as discussed in Section 4.5, no problems are foreseen provided adequate mitigation measures are taken.

There are not expected to be any impacts on the existing utility infrastructure in the area. Possible plans by the CNR for the area will not be affected by the waste management facility.

Route 126 Site

Should this site be selected, as it is currently Crown land, the transfer of the required land would be subject to a review process to ascertain if the proposed transfer would be in the best public interest. The transfer would require the Lieutenant-Governor-in-Council's approval.

Although no negative impacts on the Crown lands or the few private land holdings adjacent to the site are anticipated, the implementation of a solid waste management facility would ensure the removal of this land from softwood production for 60-80 years. As indicated in Section 2.6.2, the area surrounding the site is primarily woodlands and the remoteness of the site limits its current uses to logging. The site itself has already been partially harvested for its merchantable timber; the development of the waste management facility is not expected to affect logging activities on adjacent land.

No major impacts are expected on the recreational use of the site itself. At present, there is evidence of hiking and cross-country skiing on the site and in the surrounding area. However, the development of the site as a waste management facility will not restrict the use of the adjoining properties for such activities. The upgrading of the Melville Road will provide improved access to the Crown Lands for recreational and other uses.

Fishing of trout and salmon in the Cocagne River may possibly be impacted if leachate is discharged from the landfill; however, no problems are foreseen if adequate mitigation measures are taken (see Section 4.5).

Where deer and moose habitat is concerned, the loss of 14½% of the entire suitable wintering area habitat in a 3300 ha block in and around the Route 126 Site would lead to a decline in deer and moose populations. Some emigrating individuals may be accommodated in slightly superior wintering area habitat tracts of land to the west, east, and north of the site. The proposed border shift would mean that approximately 50 ha of suitable wintering area habitat would be saved. This is expected to reduce the magnitude of population declines.

4.6.2 TRAFFIC AND TRANSPORTATION

The operation of the regional waste management facility involves the transportation of thousands of tonnes of solid waste from all over the counties of Westmorland and Albert. This will require over 80 truck trips per day plus a similar amount of smaller vehicles. Both the size of this transportation task and the nature of the cargo presents a number of possibilities for negative impacts.

4.6.2.1 Impacts

This document has identified and assessed the following areas of impact.

Requirement for Access Road Upgrading

The three sites all require the construction of all-weather access roads and intersections. The Delong Drive Site also requires the upgrading of Delong Drive from the site to the entrance to the CN Humpyard if the Delong Drive access is used.

Traffic Congestion

The three sites under consideration have direct access to major roads or highways. The amount of traffic that will be generated by the waste management facility operation will be insignificant in terms of the existing traffic levels on these routes. With a few exceptions, the routes that will be impacted by the waste management facility operation are easily handling their peak traffic flows and will also be able to handle the additional traffic. The potential areas of concern include the summer months at Magnetic Hill (Route 126 Site), the intersection of Berry Mills Road and the site access road and congestion at the intersection of Edinburgh and St. George streets (Delong Drive Site and Berry Mills Road Site). None of these concerns are classed as significant given the volume of proposed increase in traffic to existing traffic.

Traffic Safety

Traffic safety is always a concern for a project that will generate any level of traffic. The potential traffic safety concerns include: traffic entering and leaving the site access road at Berry Mills Road; Delong Drive or Berry Mills Road Site access road crossing the CN line; and increase in traffic congestion at the Magnetic Hill area, steep grades on Route 126, and pedestrian and vehicle traffic around the Magnetic Hill School area.

Litter Falling from Vehicles

The transportation of waste in open trucks and trailers can lead to a littering problem. Unless loads are properly covered and secured, loss of part or all of the load can result. If this occurs, the routes into the site will become littered which can become a safety and an environmental problem.

4.6.2.2 Mitigation Measures

The following mitigation measures have been identified to address the potential traffic and transportation impacts.

All Sites

1. An all weather access road will be engineered and constructed. This road will meet the traffic level, safety and environmental requirements.
2. Strict enforcement of waste transportation regulations will be the responsibility of all jurisdictions. The operators of the waste management facility will also have an important role by educating its customers and only accepting loads that meet the transportation regulations.
3. With the cooperation of the various jurisdictions, the waste management facility operators will monitor traffic levels, investigate complaints and accidents.

Delong Drive

1. If Delong Drive is used as the access, it will be upgraded from the CN Humpyard to the site entrance.
2. The waste management facility operator will work with the industrial park operator and city officials to address any littering or traffic congestion problems.
3. The City of Moncton is proceeding to install traffic light at the intersection of Edinburgh and St. George to address the current traffic congestion problems.
4. If the Berry Mills Road is used as the site access, mitigation measures will be as described below.

Berry Mills Road

1. The construction of the intersection of the site access road and Berry Mills Road will include a left turn lane for traffic turning into the site and possibly other traffic safety features such as warning signs or lights, and acceleration and deceleration lanes.

2. Traffic control lights will be installed at the intersection of the access road and the CN rail line.

Route 126 Site

1. Caution signs and/or warning lights will be installed at the intersection of the access road and Route 126.

2. Current plans to address traffic congestion and safety problem at Magnetic Hill Centre should proceed including turning lanes and traffic control signals.

3. Although the best mitigation measure for steep grades on Route 126 would be reconstruction of the road, it is not warranted in this case. Additional effort on snow removal and application of sand/salt will actually improve conditions compared to the existing situation.

4. If use of the Indian Mountain Road by truck traffic becomes a problem, it could be addressed by limiting trucking to local as opposed to through trucking.

5.0 MONITORING REQUIREMENTS

A monitoring program is an integral component of an impact assessment. Often, the quantification of impacts cannot be done until the project is in operation (e.g., the amount of leachate produced). At present, these impacts can only be predicted approximately from theoretical considerations or from experience elsewhere. Monitoring involves a series of repeated measurements, throughout the life of the project, in order to determine whether or not the impact predictions are accurate. Monitoring can be classified into: compliance monitoring, and environmental effects monitoring. Compliance monitoring is proposed to ensure that regulated levels of parameters in discharges are met. Environmental effects monitoring is used to assess the accuracy of the predicted impacts.

A monitoring program should be amenable to change as experience is gained and the physical situation changes. Only a conceptual program is proposed thus far; however, it will be finalized in the course of the final design of the waste management facility and reviewed on a regular basis throughout the life of the project.

Although it is anticipated that the environmental technician on staff will sample and monitor as part of his/her regular duties, outside independent agencies will also be employed for sample collection and for all testing. Reports of all tests will be provided to the N.B.D.O.E. and to a local citizens committee, independent of the Commission, which is recommended to be set up as a part of the compliance system.

Sampling of fish populations on the Cocagne River was done in April, 1991, when conditions were not optimal for electrofishing. Spot checks were prevented because of high water conditions. If the Route 126 Site is selected for landfill development, further baseline data must be collected and analyzed. This baseline data would include a cruise to locate salmon pools on the Cocagne River between stations #18A and #19A, density checks for salmonoids at 3 points on the Cocagne River, and quantitative sampling for benthic macro-invertebrates so that Shannon Diversity Index values are available for 3-5 points on the Cocagne River.

5.1 Compliance Monitoring

5.1.1 GROUNDWATER MONITORING

A groundwater monitoring plan will include monitoring points adjacent to and 50 to 100 metres down-gradient from the active cells. Samples from the outermost set of piezometers and up-gradient locations will provide background information. Data collected from monitoring points adjacent to the landfill will serve as early indicator of chemical changes in the groundwater.

Background chemical data for groundwater and surface water will be acquired prior to landfill operation.

The monitoring wells will be established in the shallow till, the shallow bedrock and in a deep flow system. The location of these monitoring points, as well as the collection of four (4) samples/year by a trained technician from each monitoring point will be adequate to detect leachate migration and permit sufficient time to take remedial action before the contaminant migrates off-site. The actual number of monitoring points required will be dependent on the size and shape of the landfill.

5.1.2 SURFACE WATER QUALITY MONITORING

A surface water quality monitoring program will include end-of-pipe monitoring to ensure the detection of any accidental releases of leachate. As well, leachate will be analysed on a regular basis to ensure that effluent standards are met.

5.2 Environmental Effects Monitoring

5.2.1 MONITORING SURFACE WATERCOURSES FOR SEDIMENT

Regardless of site choice, a program will be set up to monitor releases of sediment into Michael's Creek, Somers Creek, or the Cocagne River. In addition to tracing the annual periodicity of sediment pulses in the watercourse, settling pond discharge will be monitored. The most appropriate time will be following heavy rainfall events.

On Michael's Creek, it is recommended that monitoring take place at stations #12 and #14 (Exhibit 2-15).

For the Berry Mills Road Site, the most suitable access points for sampling on Somers Creek are 6A and 9A, or 6A and station #10 (Exhibit 2-15).

It is recommended that four locations be established on the mainstem of the Cocagne River and its tributaries if the Route 126 Site is chosen. The most suitable locations include stations #17 and 18A for control stations, and points above station #19A and station #20 for experimental stations (Exhibit 2-16).

It is important to note that the above monitoring stations are suggested locations; the final locations and frequency of monitoring will be determined in consultation with appropriate government agencies.

5.2.2 MONITORING SURFACE WATERCOURSES FOR LEACHATE

Regardless of the fact that leachate will be directed to the Greater Moncton Sewage Commission Plant, a regular monitoring program will be undertaken in Michael's Creek, Somers Creek or the Cocagne River for the presence of leachate. Monitoring will include samples taken from the leachate, the water column and the sediment. All three sources are included to account for potential leachate releases during a storm. A subsequent change in sediment chemistry would then trigger more frequent sample collections.

Monitoring/sampling station locations and sampling frequency for Michael's Creek, Somers Creek or the Cocagne River will be determined in consultation with appropriate government agencies. However, the following locations are recommended:

- For the Delong Drive Site, sampling could take place at stations #12 and #14 on Michael's Creek.
- For the Berry Mills Road Site, sampling could take place at Stations #7, #8 and #10.
- For the Route 126 Site, monitoring could take place at the property border, the mouths of the two unnamed tributaries on the northern border of the site, and station #19A.

For both the Delong Drive Site and Berry Mills Road Site, in order to prevent contamination of groundwater, monitoring will also take place to ensure that leaks do not occur in the pipes transporting the leachate to the sewage collection system. Leak testing of the pipes, similar to that after installation by a Contractor, will be carried out.

5.2.3 SURFACE WATER MONITORING VARIABLES AND TIMETABLES

For the surface watercourses identified in sections 5.2.1 and 5.2.2, the following variables will be measured:

- flow rate, pH, alkalinity, BOD, dissolved O_2, colour, total N, total P, DOC, suspended and dissolved solids, the heavy metals Al, As, Cd, Cl, Cu, Fe, Hg, Mn, Pb, and Zn, total and faecal coliforms, E. coli., and PCB.

All variables, with the exception of dissolved O_2, will be recorded for all monitoring stations four (4) times/year for at least the first five years of operation. Sampling will occur at a similar time and under similar flow conditions each year to allow for comparisons. These times will be: Jan.-Feb., Mar.-Apr., Jul.-Aug., and Oct.-Nov. Dissolved O_2 values, on the other hand, will only be recorded twice yearly during low flow periods. After the first five (5) years of landfill operation, monitoring of these variables may be reduced. Collection of water samples will be done by a biologist trained in proper sampling procedures.

5.2.4 MONITORING OF BENTHIC INVERTEBRATES AND AQUATIC RESOURCES

As a supplement to water quality monitoring, a regular monitoring program for benthic invertebrates and fish populations (electrofishing) will be set up regardless of which site is selected.

Aquatic habitat monitoring should be performed as follows. The indicator is aquatic macro-invertebrate diversity.

Delong Drive Site

Michael's Creek:

No sampling will be required for aquatic macro-invertebrates and no sampling will be required for fish.

Berry Mills Road Site

Jonathan Creek:

Aquatic invertebrate sampling will be performed yearly during January, April, July and October at stations #2A and #3A. Five samples/station should be satisfactory.

Diversity index values (Hutt, 1988) will be calculated and comparisons made for a minimum of three years.

Electrofishing will be performed in April, July and October of each year to obtain qualitative information at least on species composition in Jonathan Creek.

Somers Creek:

Aquatic invertebrate sampling will be performed yearly during January, April, July and October at:
1) the confluence of the streams containing stations #7 and #8,
2) a point above the outfall from the sedimentation pond, and
3) station #9a.
Five samples/station should be satisfactory.

Diversity index values (Hutt, 1988) will be calculated and comparisons made for a minimum of three years (i.e. six sampling occasions).

Electrofishing will be performed at the above sampling stations in April, July and October of each year to get qualitative information at least on species composition in Somers Creek.

Route 126 Site

Shaw Brook:

Aquatic invertebrate sampling will be similar to that recommended for Jonathan Creek and Somers Creek at stations #21 and #22. Qualitative information on fish species composition will also be obtained from electrofishing at these stations.

Cocagne River (mainstem):

Aquatic invertebrate sampling will be similar to that recommended for Jonathan Creek, Somers Creek and Shaw Brook at stations #18A and #19A.

The highest priority for electrofishing (i.e. species composition and density estimates) will also be placed on stations #18A and #19A.

Petitcodiac River

No work will be carried out on the Petitcodiac River mainstem.

Any significant change in fish populations will be followed by more intensive water quality monitoring and consideration of more stringent mitigation measures if releases from the landfill are confirmed as the probably cause.

5.2.5 MONITORING OF SOCIO-ECONOMIC IMPACTS

In order to verify the predictions of the EIA, several of the potential socio-economic impacts will be monitored.

A record will be kept of various complaints regarding noise, litter and other nuisance parameters near the site and along haul routes. Depending on the nature of the complaints, mitigative measures can be taken (e.g. requirements to maintain a cover on trucks entering the site). The location and reason for the presence of any nuisance animals like rats and skunks will also be monitored.

Applications for building permits and subdivision plans will be reviewed regularly to determine if development will encroach on the chosen site. Also, for the Delong Drive Site and Berry Mills Road Site, the expansion of the Moncton Industrial Park in the direction of the facility will be monitored. If unacceptable encroachment may occur, proper authorities will be approached to ensure that all parties are aware of potential problems.

Unregulated dumping of waste throughout the Region will be monitored by the future Commission, municipalities, and N.B.D.O.E. Should a violation of the Clean Environment Act occur, action must be taken by the N.B.D.O.E.

6.0 COSTS OF SITES

Capital costs and operation and maintenance costs have been developed for each of the proposed sites. The grant structure of the N.B.D.O.E. has been taken into consideration and the annual cost of the remaining capital debt of the Solid Waste Commission calculated. Based on a 50 percent capital grant and loan repayment over a 5 year period at an 11 percent interest rate, the tipping fee (costs per tonne) for use of the landfill at each site is shown in Table 6.1.

Using cost figures presented in the recycling study recently conducted by the N.B.D.O.E. a comparison of costs for a landfill only system versus the cost of an integrated facility which would divert over fifty percent of the solid waste from the landfill have been prepared. These are shown in Table 6.2 and include collection, transportation and disposal. Repayment of the capital debt on the recycling/composting component is based on a term of 20 years whereas the landfill component is based on a term of 5 years.

TABLE 6.1

Comparison Costs of Landfill Sites

	Capital Cost	O & M Costs	Cost/tonne
DELONG DRIVE Access Berry Mills Road 600 acres	$12 205 000	$1 300 000	$34.28
DELONG DRIVE Access Delong Drive 600 acres	11 865 000	1 300 000	33.74
BERRY MILLS ROAD Access Berry Mills Road 600 acres 1272 acres	12 189 000	1 300 000	34.25 35.47
BERRY MILLS ROAD Access Delong Drive 600 acres 1272 acres	13 264 000	1 300 000	35.94 37.17
ROUTE 126 700 acres	11 713 000	1 650 000	37.57

TABLE 6.2

Comparison Costs of Waste Management Systems

A.	Sanitary Landfill System Only	
	Capital Cost Landfill	$12 115 000
	Disposal Cost Landfill	$35/tonne
	Collection and Transportation Cost (residential)	$49/tonne
	Total Cost per Tonne	$84
	Cost per Household	$67
B.	Central Processing Facility with Recycling and Composting and Balance to Sanitary Landfill	
	Capital Cost Landfill	$10 615 000
	Capital Cost Recycling/Composting	$12 700 000
	Landfill Disposal*	$23/tonne
	Recycling, Composting, Collection	$82/tonne
	Total Cost per Household	$100

* Based on 86000 tonnes.

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APPENDIX A

Guidelines and Terms of Reference for an Environmental Impact Assessment of the Westmorland/Albert Integrated Waste Management Facility.

GUIDELINES FOR AN ENVIRONMENTAL IMPACT ASSESSMENT

WESTMORLAND-ALBERT INTEGRATED WASTE MANAGEMENT FACILITY

Issued by the Minister of the Environment
for the Province of New Brunswick

to

THE WESTMORLAND-ALBERT SOLID WASTE PROVISIONAL COMMITTEE

March 6, 1991

1.0 INTRODUCTION 1
1.1 Westmorland-Albert Solid Waste Provisional Committee 1
1.2 Environmental Impact Assessment Process 2

2.0 METHODOLOGICAL APPROACH TO EIA 4
2.1 General 4
2.2 Study Boundaries 4
2.3 Prediction of Environmental Effects 4
2.4 Commitment to Monitoring 5
2.5 Prevention, Mitigation and Compensation 5
2.6 Public Consultation 6
2.7 Terms of Reference 6

3.0 CONDUCT OF THE STUDY AND CONTENT OF REPORT 7
3.1 Description of the Existing Environment 7
3.2 Project Description 8
3.3 Project Rationale 8
3.4 Identification and Analysis of Alternatives 8

4.0 SIGNIFICANT ISSUES 9
4.1 Socioeconomic Impacts 9
4.2 Impacts on Groundwater 9
4.3 Impacts on Surface Water 10
4.4 Human Health Impacts 10
4.5 Transportation Impacts 10
4.6 Impacts on Plants and Animals 10

1.0 INTRODUCTION

1.1 Westmorland-Albert Solid Waste Provisional Committee

The New Brunswick Department of the Environment has implemented a waste management program for the province. This plan will result in the replacement of the existing network of dumps by regional waste systems which incorporate state-of-the art facilities, collection networks and recycling operations.

The Westmorland-Albert Solid Waste Provisional Committee (SWPC) was established by the Minister of the Environment to develop and implement a long term strategy for handling the solid waste generated in the Westmorland-Albert region. The Committee, comprised of representatives from all the municipalities and local service districts in the region, has embarked on a planning process designed by the Department of the Environment. This process consists of technical studies and public consultation.

A number of studies have been conducted to date including:

Waste Audit
Overview of Waste Management in Westmorland-Albert
Waste Management Alternatives
Site Selection Criteria Scoring System
Westmorland Albert Public Attitude Study

The Committee proposes to build a sanitary landfill as the major component in its waste management strategy for the region. This landfill will replace the environmentally unsuitable dump sites presently being used in Westmorland and Albert Counties. Three potential sites have been identified as shown in the map on page 11.

The proposed waste management strategy will also include public education, waste reduction, recycling and composting.

1.2 Environmental Impact Assessment Process

Under Regulation 87-83 of the Clean Environment Act, the Westmorland-Albert Solid Waste Provisional Committee (SWPC), as the proponent of the project, was required to register the Westmorland-Albert Regional Landfill as an undertaking for Environmental Impact Assessment (EIA) screening. The proposal was registered on December 11, 1990. On December 18, 1990, the Minister of the Environment determined that the completion of an EIA was required to assess the nature and significance of the proposal's potential impacts.

The Minister of Environment has invited technical specialists from various government agencies whose jurisdictions may be affected by the undertaking to participate in a Review Committee. The agencies include:

The N.B. Department of the Environment
The N.B. Department of Natural Resources and Energy
The N.B. Department of Agriculture
The N.B. Department of Transportation
The N.B. Department of Health and Community Services
Department of Recreation, Tourism and Heritage
Environment Canada

Draft guidelines were developed to identify the important issues which must be considered in assessing the impacts of the proposed development. They also specified the approach the proponent should follow in conducting the EIA. Members of the public were invited to comment on the draft guidelines and to identify any issues of concern which did not appear in the draft document.

The final guidelines incorporate the comments and concerns received by the Minister during the public review of the draft guidelines.

On receipt of the final guidelines, the SWPC and/or its consultant is required to provide the Minister with detailed Terms of Reference which describe the approach to be used in the EIA study. The Terms of Reference are evaluated through a consultative process involving the proponent, the proponent's consultant, and the appropriate government review agencies.

Following the review of the Terms of Reference, the proponent conducts the EIA. The principle objective of the study is to predict the impacts which can be expected should the project proceed. The study, conducted in consultation with the residents from the area of potential impact, is also expected to identify methods of enhancing positive impacts and minimizing negative impacts resulting from the undertaking.

Information gathered during the study is compiled in a draft EIA report. The report is then evaluated by the Review Committee to determine whether the report adequately addresses the issues raised in the study guidelines. Should the Review Committee determine that the report does not adequately address the guidelines, the proponent is expected to make revisions to address identified deficiencies in order to advance the EIA process.

If, on the advice of the Review Committee, the Minister is satisfied that the EIA report is adequate, the next step is to involve the public in discussing the impacts which the final report describes.

A summary of the final report is prepared on behalf of the Minister to assist members of the public in becoming familiar with the information. The Review Committee also prepares a General Review Statement summarizing its comments on the EIA study document. These documents are released for a period of at least 30 days for public review and comment. At this time, the schedule and location(s) of public meeting(s) are announced by the Minister.

Public meetings generally take place near the area where the project is being proposed and provide all interested parties with an opportunity to make comments, raise concerns or ask questions about any matter covered in the EIA study. Following the public meeting, an additional period of fifteen days is set aside for members of the public to submit further written comments to the Minister.

At the end of this period, a summary of public participation is prepared, distributed to the public and presented to the Minister.

At any time after this date, the provincial government (Lieutenant-Governor in Council) may make a decision to issue or deny an approval for the project.

Specific procedures to be followed in conducting an EIA may be found in Regulation 87-83, Environmental Impact Assessment Regulation - Clean Environment Act. A procedural summary is available in the publication entitled "Environmental Impact Assessment in New Brunswick". These documents may be obtained from the Department of the Environment at the address below:

Manager, Environmental Impact Assessment Section
Environmental Planning and Sciences Branch
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2.0 METHODOLOGICAL APPROACH TO EIA

2.1 General

The Environmental Impact Assessment process results in a detailed study of potential environmental impacts and the methods which may be used to control those effects.

To provide a focus for the EIA, ecosystem components which are potentially at risk and which are considered of significant value must be identified in the study. This value is based not only upon scientific or economic judgements, but also upon subjective social values and public perceptions.

These guidelines highlight, in Section 4.0, a number of specific issues to be addressed. However, the study should not be limited by this framework. Should additional issues arise out of discussion with members of the review committee, regulatory agencies or members of the public, the proponent is encouraged to incorporate these into the analysis of the project's impact.

2.2 Study Boundaries

The proponent must clearly define the boundaries of the study in time and space.

The temporal scope of the study (the length of time considered) must reflect the construction period, the life expectancy of the project, and any potential residual impacts which may remain beyond the operating period and site rehabilitation.

The proponent must clearly define and justify the spatial boundaries of the study (the distance from the site) based on the potential for significant impact. Spatial boundaries for the proposed project must incorporate areas affected by noise, odours, visual impacts, and movement of leachate into water resources. The proponent must include areas affected by transportation of materials to the site and those areas between the landfill and any other waste management sites, if selected, which will be incorporated into the overall waste management strategy (transfer facilities, recycling depots, incinerators, temporary hazardous waste storage).

2.3 Prediction of Environmental Effects

The main focus of the environmental impact assessment must be to predict changes to the environment which may result from the undertaking. Predictions must consider all aspects and phases of the project, and any secondary, cumulative or synergistic effects.

EIA predictions are generally based on a combination of objective and subjective evaluation. The use of objective (measurable) analysis is **strongly preferred**. However, in recognition of the factors which limit the ability to predict environmental responses, it is expected under certain circumstances that predictions may be based **in part** on subjective evaluation using professional judgement, speculation or experience. In consideration of this, predictive statements should be accompanied by a discussion of the limitations of the analysis, as well as references to supporting documentation.

Predictions must be made regarding the nature, magnitude, duration and distribution of the project's environmental effects. These predictions must:

1. Facilitate decision-making with respect to the proposed project.
2. Clearly specify the degree of uncertainty inherent in the projections.
3. Clearly identify impacts with respect to tolerance levels of organisms in the environment.
4. Be amenable to testing through ongoing monitoring.

The EIA must also evaluate the **significance of predicted impacts**. In order to do this, objective criteria for determining if these impacts are significant should be established through consultation with the technical review committee prior to the conduct of the studies.

The significance of project-induced changes on valued environmental components should be stated in the EIA Report in the most unambiguous manner possible.

2.4 Commitment to Monitoring

A well defined program of monitoring the effects of the project must be outlined in the EIA. This program must provide information:

1. To test the predictions of the EIA study.
2. To evaluate the effectiveness of the measures used to prevent or minimize environmental impacts.

The monitoring program must be based upon accurate baseline information of the existing environment (physical, biological, socioeconomic). The proponent is expected to collect the necessary information through existing data sources or through primary research (field work, laboratory testing).

Where the EIA predictions are not based on objective information, the monitoring program must be designed, where possible, to collect any data not previously available.

2.5 Prevention, Mitigation and Compensation

The study must describe alternative methods of preventing or mitigating (minimizing) damage to the environment.

Specific circumstances under which mitigation measures will be implemented must be clearly defined by the proponent.

Contingency plans must be generated:

1. For use in the event of an environmental emergency attributable to the project, within the spatial boundaries of the study.

2. For use in the event of significant impacts, attributable to the project, which are detected through monitoring. This plan must be designed to be implemented should impacts be detected during construction, operation, rehabilitation, or following abandonment of the facility.

The study must outline a plan for a compensation mechanism to be used in the event that environmental damage occurs. This plan must be developed through consultation with federal and provincial agencies and other stakeholders.

2.6 Public Consultation

The SWPC should conduct ongoing consultation with persons and organizations potentially affected by the construction and operation of the facility, and should continue to incorporate their concerns into the study. The objectives of this consultation should be:

1. To ensure that affected publics are well informed, prior to the government's approval decision, as to nature and extent of environmental costs as well as the benefits attributable to the proposed project.
2. To ensure that the values and concerns of the public are incorporated and adequately addressed in the study.

2.7 Terms of Reference

The proponent is required to submit detailed terms of reference in response to the EIA guidelines. These should describe the methods proposed for carrying out the EIA, and the means by which the SWPC will consult with the public during the course of the EIA study.

The terms of reference will be examined by the Review Committee, and comments may be provided to the proponent.

3.0 CONDUCT OF THE STUDY AND CONTENT OF REPORT

3.1 Description of the Existing Environment

Section 31.1(1) of the Clean Environment Act, defines "environment" as:

(a) air, water, or soil

(b) plant and animal life including human life, and

(c) the social, economic, cultural and aesthetic conditions that influence the life of humans or a community as they are related to the matters described in (a) and (b).

The EIA Report should describe the existing environment within the study boundaries to provide the reader with a basic understanding of the potential interactions with the proposed project.

A description of each site must include a description of the terrain, an analysis of soil characteristics, detailed maps and discussion of the bedrock and surficial geology.

To facilitate analysis of odour and litter impacts, data on wind velocities and direction must be included in the study. Factors, such as rainfall and snowfall, affecting facility design and prediction of runoff volumes and frequencies must be considered.

The study must include an inventory of potentially affected biological resources which are determined to be valued ecosystem components (ie wildlife and habitat).

The study must clearly document the presence of any unique, infrequently encountered, vulnerable, rare, or endangered species, occurrences or habitat that may be affected by construction or operational activities.

The current status and uses of potentially affected watercourses and groundwater resources, including springs, must be described. Relate the potential for impact to the characteristics of the bedrock and surficial geography.

Current land use (recreational, agricultural, residential, industrial) within the spatial boundaries of the study must be documented. Population densities adjacent to the sites must be recorded.

Identify and discuss the implications of any applicable Municipal, Provincial or Federal legislation pertaining to the construction and operation of the facility. Discuss the implications of the Department of Natural Resources and Energy Forest Management Manual's harvesting and utilization requirements which would apply should the selected site be located on Crown land.

Current usage and condition of roads leading to the facility must be described.

3.2 Project Description

The EIA report must clearly describe, in detail, all aspects of the project from the planning phase through construction, operation (including maintenance activities), abandonment and site rehabilitation.

The location, size, capacity, boundaries, physical facilities (including roads, security systems, leachate collection systems) and layout for the proposed facility must be described.

The proposed nature and locations, if selected, of other waste management facilities (transfer facilities, recycling depots, composting areas, incinerators, temporary hazardous waste storage) should be outlined in the study.

The amounts, origins and components of the waste must be predicted.

The amounts and characteristics of all effluents, both liquid and gaseous must be predicted.

Describe the transportation routes to the site with expected volumes of traffic.

3.3 Project Rationale

The report must provide clear justification for the project in order to allow for an evaluation of the relative costs and benefits of the proposed development.

3.4 Identification and Analysis of Alternatives

The study should evaluate alternatives to the project as proposed. This analysis will contribute to a further understanding of the project rationale and will facilitate decision-making with respect to its acceptability.

The proposed project should be compared to the following alternatives with reference to potential for environmental impact:

(a) The null alternative. The study must examine the implications of not proceeding with the project with reference to economic, environmental and social factors.

(b) Alternative locations. A description of the methodology used to select a site and the results of the site selection process should be presented. Where existing government guidelines have been used in the siting process, those guidelines should be referenced.

(c) Alternative methods for prevention or mitigation of environmental impacts. These alternatives should be compared on the basis of effectiveness for environmental protection for the entire study area and for the entire lifespan of the project, including abandonment. Discuss the implications for environmental impact of alternative or supplementary waste management strategies (waste reduction, reuse and recycling, diversion of household and commercial toxic waste, incineration). Discuss the costs of each of the alternatives.

4.0 SIGNIFICANT ISSUES

4.1 Socioeconomic Impacts

If the proponent intends to proceed with this development in an area which has been relatively undisturbed, the EIA Report should consider the effects that the project may have on traditional resource uses such as angling, hunting,trapping and camping. Discuss the potential for impact upon tourism, with particular reference to the Indian Mountain Road site near Magnetic Hill.

Predict the impacts of the proposal on the community with respect to aesthetics, odour, litter, noise and abuse of access roads. Discuss the potential for increased predation risk to livestock from coyotes attracted to the site.

The impact of the proposed facility on property values should be evaluated within the limits of the determined project boundaries.

The effect on present and future land use patterns and infrastructure requirements should be predicted with a focus on residential and agricultural uses. Impacts on amenities should be evaluated.

4.2 Impacts on Groundwater

The impact of the proposed facility on groundwater (including springs) for domestic, agricultural, industrial, and municipal uses should be assessed. The impacts of accidental spills on aquifers should be predicted with the aid of detailed geological and geophysical maps. Consideration should be given to existing and potential groundwater use.

4.3 Impacts on Surface Water

The impact of the proposed facility on surface water resources should be assessed. The Fisheries Act, administered by Fisheries and Oceans Canada, prohibits any activity which would adversely impact fish habitat. The analysis should focus on surface water as it relates to the maintenance of existing water quality, fish populations and compatibility with existing and potential uses for recreation and agriculture (eg. crops and livestock).

4.4 Human Health Impacts

The effect of the facility in the proposed location on human health and safety related to drinking water, gases potentially released from the landfill, traffic, fire and nuisance animals should be evaluated.

4.5 Transportation Impacts

Predict the impacts of traffic to and from the site, and any other waste management sites if selected, with reference to noise, safety, risks of spills, and property values.

4.6 Impacts on Plants and Animals

Predict the impacts of construction and operation of the facility on plants and animals and their habitat. Include impacts to local deer populations, populations of rare or endangered plant and animal species as well as other plant and animal populations.

Describe the area and volume of wood to be removed from the site during construction. Predict the potential for impact on adjacent forest growth.

Draft

TERMS OF REFERENCE
FOR AN
ENVIRONMENTAL IMPACT ASSESSMENT
OF THE WESTMORLAND/ALBERT
INTEGRATED WASTE MANAGEMENT FACILITY

Submitted by:

Westmorland/Albert Solid Waste Provisional Committee

Consultant:

Acadia Consultant and Inspectors Limited
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Date:

April 4, 1991

1.0 INTRODUCTION

1.1 Westmorland/Albert Solid Waste Provisional Committee

The New Brunswick Department of the Environment (NBDOE) has implemented a waste management program for the Province. This plan will result in the replacement of the existing network of dumps by regional waste systems which incorporate state-of-the-art facilities, collection networks, and recycling operations.

The Westmorland/Albert Solid Waste Provisional Committee (WASWPC) was established by the Minister of the Environment to develop and implement a long term strategy for handling the solid waste generated in the Westmorland/Albert Region. The Committee, comprised of representatives from all the municipalities and local service districts in the Region, has embarked on a planning process designed by the Department of the Environment. This process consists of technical studies and public consultation.

A number of studies have been conducted to date including:

- Waste Audit
- Waste Management Alternatives
- Overview of Waste Management in Westmorland/Albert
- Site Selection Criteria Scoring System
- Westmorland/Albert Public Attitude Study
- Constraint Mapping for Preliminary Site Identification
- Site Selection Report
- Collection and Transportation Analysis

The Committee proposes to build a sanitary landfill as the major component in its waste management strategy for the Region. This landfill will replace the environmentally unsuitable dump sites presently being used in Westmorland and Albert Counties. Three potential sites have been identified which meet siting criteria. The project has been registered under the Environmental Impact Assessment Regulation of the New Brunswick Clean Environment Act (Regulation 87-83).

The proposed waste management strategy will include public education, waste reduction, recycling, and composting. The integrated waste management facility will include administration and maintenance areas, the recycling operation, the sanitary landfill, a leachate treatment system, a composting operation, construction and demolition waste area, and other components in the near future.

1.2 Environmental Impact Assessment Process

Regulation 87-83 describes the process to be followed in order for the proponent to obtain a decision from the Lieutenant-Governor-in-Council for the project. The steps in the process are outlined below:

- Proponent (WASWPC) registers the proposed project with NBDOE.
- The project is determined to be of sufficient impact to warrant a detailed EIA.
- Draft guidelines are prepared by NBDOE with the aid of a Review Committee comprised of technical specialists from various government agencies.
- Guidelines are then reviewed by the Public.
- Final guidelines are issued to the WASWPC.
- WASWPC submits a draft Terms of Reference in response to EIA guidelines.
- Terms of Reference are finalized through a consultative process.
- The WASWPC undertakes the EIA.
- A draft EIA is filed with the Minister of NBDOE for review.
- The draft EIA is reviewed and modified as required.
- The final EIA report is filed.
- The Minister accepts for public review.
- An EIA Summary Report and a General Review Statement are prepared.
- Public meetings are held to address the final EIA report.

- Public comments and concerns are submitted to the Minister.

- The Lieutenant-Governor-in-Council decides on acceptability of the project.

NBDOE has screened the project and confirmed that a full EIA is required. Draft guidelines for an environmental assessment of the project were issued for public review. No written submissions were received from the Public and final guidelines have been prepared by NBDOE. These draft Terms of reference are based on the final guidelines and further discussions with representatives of WASWPC and NBDOE.

The fundamental components to be considered in an EIA include: the project rationale, site selection process, project description, description of the existing environment and valued ecosystem components, establishment of a context of significance for impacts, prediction of environmental effects, and a description of monitoring and mitigation measures.

2.0 STUDY APPROACH

The EIA study will accumulate available information previously prepared for WASWPC including the reports listed in Section 1.1. Detailed base line data will be obtained during the EIA process. Environmental impact assessment and mitigation will focus on the application of recognized siting and design guidelines. Generic project description, monitoring, and contingency plans will be applicable to the site(s).

Site specific environmental impact assessments will be undertaken on the site(s). The project description, identification of environmental concerns, and the description of monitoring and mitigation measures will be both generic and specific for the site(s). The prediction of potential environmental effects will be made on the basis of available site specific information.

The information incorporated into the report will describe how the decision to establish an integrated waste management facility was arrived at, the region to be served, and the population distribution within the region. The project rationale will provide a summary of information previously prepared by the WASWPC.

The methodology used for selecting alternative regional sites will be reviewed. A description of previous studies on behalf of WASWPC and previously provided to the Department of Environment will be presented, including information on site selection criteria, investigations conducted, and the results of the site selection process.

The review of environmental effects associated with the proposed Westmorland/Albert Integrated Waste Management Facility will be conducted by a team of specialists in waste management, transportation, socio-economic analysis, groundwater assessment, fisheries, wildlife, and environmental management. In the definition of the project, the team of specialists will work closely with the WASWPC. The project will be described in accordance with design guidelines to meet existing permitting requirements of the Province of New Brunswick and the Government of Canada.

2.1 Identification of Valued Ecosystem Components

Valued Ecosystem Components (VECs) are those aspects of the ecosystem or associated socio-economic system which are considered to be of value to humans. The components include those of commercial or social importance, as well as those that are essential to the food web or are reliable indicators of environmental change. Two steps will be taken to identify the VECs for this project. First, those parameters for which provincial or federal regulations are in place (for example, the level of contaminants in groundwater) will be identified. Second, available information on the environment surrounding the proposed sites will be used and incorporated with discussions held with resource managers and user groups. Field programs will be used to supplement available information.

2.2 Study Boundaries

The current approach to the evaluation of environmental impact involves both temporal and spatial assessment of the physical and biological properties of the site. Temporal bounds for the project will be established in three time frames: construction, operation, and post-closure. Duration for each of these phases will be determined and used as temporal bounds. Spatial bounds for the socio-economic aspects will focus on the economic activity generated by the project, together with an assessment of the services and facilities available within the immediate area. These immediate bounds will also be used for the assessment of visual and noise effects. The spatial bounds for the biological aspects will be the buffer zones around the site, the site itself, and adjacent water courses. Particular emphasis will be placed on the surface water bodies and their associated biological components.

2.3 Assessment of Environmental Impacts

Impact assessment will focus on those aspects of the environment perceived to be at greatest risk, such as surface water bodies and their associated biological components, and valued groundwater resources. Guidelines issued by NBDOE require that a context for the significance of impacts be established, and that the criteria for significance of an impact be objective. The goal is to provide a clear indication of action levels for those parameters to be monitored. Regulated or recommended allowance levels for deviation from the background environment will be used as a basis against which to measure significance. For example, any effluent streams with the potential to exceed regulated levels of contaminants will be judged to have significant impact and appropriate mitigation measures described. Any deviation from background will also be judged to be significant if the predicted changes would cause a significant change in a process or state within the bounded area, resulting in a sustained depression of fitness or density below naturally occurring levels. Where such changes are predicted, mitigation measures will be recommended and monitoring programs will be designed to assess the effectiveness of mitigation measures.

2.4 Mitigation, Monitoring, and Compensation

Where potentially significant impacts are predicted, mitigation measures will be described. These may involve modifications or restrictions on the development or operation of the site, or specific actions designed to protect the resource at risk (for example, site development plan for erosion control). In some cases, the prediction of impacts may not be precise because of the nature of the interaction. For these cases, a monitoring program will be proposed and specific action levels established for situations where monitoring program indicates corrective action needs to be taken. Contingency plans and compensation mechanisms will be developed for implementation in the vent that environmental damage attributable to the project (emergency or detected through monitoring) occurs.

2.5 Public Consultation

The WASWPC will conduct ongoing consultation with persons and organizations potentially affected by the construction and operation of the facility and will incorporate concerns into the study.

2.6 Summary

In summary, the steps in assessing the potential impacts for a given site will be as follows:

1) Develop a general understanding of the existing socio-economic, physical, and biological environment within the spatial boundaries of the site.

2) Obtain a description of project activities, their timing, and duration.

3) Identify the resources possibly affected by the project.

4) Consult with persons and organizations potentially affected by the facility.

5) Prescribe alternative mitigation measures where a significant risk is identified.

6) Recommend a monitoring program for those interactions where the impact cannot be precisely defined and where efficiency of mitigation measures need to be checked.

7) Describe action levels related to the monitoring programs, including levels at which actions must be taken to prevent environmental degradation.

8) Develop contingency plans for implementation in the event of environmental damage and compensation mechanisms to be used.

Further detail on these steps are provided in Section 3.

3.0 CONDUCT OF THE STUDY

3.1 Description of the Existing Environment

The description of the existing environment will include social systems, biological and physical systems, aesthetics, and amenities as well as transportation systems. The components of each system will initially be identified as present or absent and the extent and sensitivity of each component will be known in general terms based on available information. A more detailed description may be required for resources where potential for impacts is identified. Relevant information on the existing environment will be obtained from the following sources:

- review of published and unpublished reference sources;

- review of available maps and aerial photographs;
- discussions with resource managers and user groups; and
- field investigations where appropriate, to supplement available information.

3.1.1 TERRAIN AND UNDERLYING GEOLOGY AND HYDROGEOLOGY

This will involve a detailed review of geological and hydrogeological data at the proposed site(s). Some field work has already been undertaken at the site(s). This will be supplemented by radar imagery, a geophysical survey, and further test drilling.

Additional piezometers will be constructed to identify specifics relating to geology, groundwater flow, and recharge/discharge conditions. Potential sites for additional groundwater monitoring wells will be evaluated for both suitability and accessibility.

3.1.2 SOIL CHARACTERISTICS

Erosion of fine-grained surface materials increases sediment loading and can result in serious environmental problems. Soil analysis results from previous field investigations at the site(s) will be used to estimate erosion rates and the potential for sedimentation.

3.1.3 SURFACE WATERCOURSES

Two water samples at two or three locations downstream of each site would be collected at the time of aquatic biological sampling. Parameters to be analyzed include pH, alkalinity, (NO_3), (NO_2^-), (PO_4^{3-}), turbidity, heavy metals (aluminum, cadmium, copper, iron, lead, mercury, and zinc), and suspended solids. The levels of coliform and faecal coliform bacteria, BOD and COD will also be determined. Results will be used to describe background levels prior to facility development.

3.1.4 BIOLOGICAL SETTING

The significant issue of biological assessment will also be to characterize the existing environment in the vicinity of the site(s) and predict the impacts of construction and facility operation on organisms and their habitat. Examples include impacts to local deer populations, populations of rare or endangered species, adjacent forest growth, and other plant and animal populations. The variety of wildlife (especially the presence or absence of endangered species) and the location of potentially sensitive wildlife habitats will be identified. At the outset of the project, habitat evaluations using aerial photographs and discussions with regional biologists will confirm the apparent presence or absence of sensitive wildlife habitats.

The proposed sites are within the Petitcodiac and Cocagne River watersheds. The operational phase may influence the quality of fish habitat and pose a risk to salmonoid populations. Therefore, in addition to evaluating impacts on local deer populations, forest stands, and other terrestrial and aquatic plants, the presence of fish and benthic invertebrates will be determined by carrying out electrofishing spot checks and analyzing kick sampler contents (i.e., invertebrate diversity). The streams involved will include Somers Creek, which is a tributary of the Petitcodiac and may contain a resident population of non-anadromous Salvelinus Fontinalis (Brook Trout), Jonathan Creek, even though it is not expected to contain brook trout because of the barriers downstream at both Main Street and St. George Street, and the Cocagne River and two of its tributaries adjacent the site east of Route 126 which may support both brook trout and Salmo Salar (Atlantic Salmon).

3.1.6 SOCIO-ECONOMIC SYSTEM

Previous related studies have provided general information on the socio-economic resources, including land use, in the vicinity of the proposed sites. A review of the available information will provide a basis for the discussion of existing socio-economic resources. Additional data to be obtained through follow-up mapping reviews, literature research, interviews, and personal visits to the site will be used to augment existing information. The description of the socio-economic system will include:

- current land values and trends in property values and sales in the vicinity of the sites;
- the potential for agricultural, forestry, wildlife, or industrial land use in the vicinity of the site;
- existing or proposed recreational and tourist-related uses such as angling, hunting, trapping, camping, skiing, or hiking trails within the general vicinity of the site;
- aesthetic attributes of the site in the form of unique or outstanding views or landscape features;
- any historical resources which exist within the area; and
- expected growth in land use, infrastructure, or population

towards the proposed site.

3.1.7 TRANSPORTATION

Information on transportation alternatives developed during previous related studies will be reviewed and updated to include a description of the current usage and condition of roads leading to the site. This will include an assessment of the increased vehicle usage, safety aspects, noise, risk of spills, and effect on property values.

3.2 Description of Project Activities

Operational plans for the proposed landfill will be described. The description will include all phases of site development, use, and rehabilitation, focusing on significant project activities identified in the Design Guidelines. It will not include the relative merits of alternative methods, which is discussed in detail in the report: Waste Management Alternatives (ACI Limited, 1989). Project activities will be similar for each of the sites. The following project activities will be described.

3.2.1 SITE LAYOUT AND RELATED INFRASTRUCTURE

A conceptual site layout of a landfill and associated facilities will be provided for a generic site. The layout will describe:

- parking and turning areas;
- an area(s) designated to receive the waste(s);
- an area for soil removal or for stockpiling soil material to be used as cover material during operation of the landfill;
- a salvage area on which recyclable waste is separated and stored temporarily;
- a general purpose area with space for an office building, parking, and a weigh scale; and
- facilities for collection (and, if necessary, treatment) of leachate and surface runoff, including lagoons and siltation ponds.

Preliminary drawings will be prepared to show the conceptual layout for facilities, cell development, buffer zones, and drainage channels. Preliminary volume calculations for soil cover requirements will be presented and potential borrow sources will be identified. Initial development of the site, including clearing and grubbing, as well as expected construction periods for buildings, fencing, and other infrastructure will also be described.

The conceptual site layout will also include the other identified components of the integrated solid waste management facility.

3.2.2 LANDFILL OPERATION

The operation of the proposed landfill will be described for a generic site. The description will include the means by which the waste arrives at the landfill site, its method of handling to the active disposal area, and the spreading and compaction processes and equipment. General requirements for monitoring wells and gas venting , daily cover procedures, and leachate collection, monitoring and treatment (if necessary) will also be described. The description of leachate collection and treatment procedures will be site-specific, and will involve such factors as access roads, buildings, buffer zones, drainage facilities, suitability of soil and subsurface conditions, settling pond and fire pond requirements, effluent treatment facilities, and cost-effectiveness relative to availability and cover material.

3.2.3 WASTE COLLECTION AND TRANSPORTATION

A list of acceptable wastes will be prepared in consultation with the WASWPC. As well, the amounts, origins, and components of waste generated in the region will be discussed based on a review of the previous studies. Specific wastes considered as dangerous or unsuitable for disposal at the landfill site will be identified from provincial and municipal government records. Measures to control use of the landfill to include only approved wastes will be developed in consultation with industry and commercial establishments responsible for the generation of unsuitable wastes. Transportation requirements, including the type and number of vehicles, will be described as well as transportation routes to the site with expected volumes of traffic.

3.2.4 LEACHATE CONTAINMENT AND COLLECTION

Requirements for liner system at landfill sites have undergone significant changes in recent years as the process of containment migration and transport has been better understood. As expected the requirements for a liner system will vary from site to site depending on existing soil conditions. Current guidelines in New Brunswick call for a liner system, of either a natural or synthetic material. Other jurisdictions have requirements for composite liners, double liners and even leak detection systems between liners. This study will include a discussion of the options available and the relative costs and applicability to each of the site(s) being considered.

3.2.5 LEACHATE TREATMENT

Since it is anticipated that each of the site(s) presently being considered will require its own leachate treatment system (no municipal secondary treatment plant is available), a detailed investigation into the requirements and costs of a leachate treatment system will be undertaken. This study will include a discussion of the options available, effect of early or late closure of the cells, recirculation and baling of solid waste. The leachate treatment system design will consider the options available for discharge of effluent including to the City of Moncton Sewer System. It is anticipated that this study will be presented as a separate report (background document) to the EIA.

3.2.6 SITE CLOSURE AND RECLAMATION

Closure and reclamation measures, including related monitoring and treatment requirements, will be described for the site(s).

3.2.7 USER COSTS

The various cost components associated with the selected site(s), including collection, transportation, and disposal fees at the site, will be estimated.

3.3 Identification of Environmental Concerns and Mitigative Measures

NBDOE siting and design guidelines will be applied to assess environmental concerns and potential impacts associated with each site. Both the timing and duration of a project activity will be considered when assessing potential effects. Mitigative measures will be identified to reduce potential impacts, and residual concerns will be identified. In particular, the following concerns will be addressed:

- The relative importance of groundwater resources (including springs) for domestic, agricultural, industrial, and municipal uses will be assessed, and the likely impacts on these uses resulting from the proposed facility will be determined. Appropriate mitigation measures for eliminating or minimizing the impact on groundwater resources will be discussed.

- The potential for erosion within the site will be discussed, and mitigation measures to eliminate or minimize associated problems will be identified.

- The risk of disruption to sensitive fish and wildlife habitat will be identified, and, if significant risks are deemed likely, mitigative measures will be proposed.
- The impact of an integrated solid waste facility in a proposed location on human health and safety, in terms of drinking water, gases, fire and nuisance animals, will be evaluated and mitigative measures proposed where necessary.
- The impact of an integrated solid waste facility in a proposed location on property values within the spatial boundaries of the site, together with impacts on affected communities in terms of aesthetics, noise, odour, and litter, will be assessed and mitigative measures proposed where necessary.
- The potential effects of an integrated solid waste facility on land use as well as on population and infrastructure growth will be discussed and mitigative measures will be identified.
- The impacts of traffic to and from the site, with respect to noise, safety, risks of spills, and property values, will be evaluated and mitigative measures proposed.

3.4 Identification of Monitoring Requirements

Monitoring involves a series of repeated measurements of an impact over time, and may be classified into: compliance monitoring, and environmental effects monitoring. Compliance monitoring is proposed to ensure that regulated levels of parameters in discharges are met. The monitoring and reporting schedule, as well as parameters to be analyzed, will be based on federal/provincial guidelines. Environmental effects monitoring is used to assess the accuracy of the predicted impacts.

A monitoring program (particularly for groundwater and surface water) will be an integral component of the impact assessment, and will include definitions of action levels and recommendations for follow-up actions. The conceptual monitoring network defined for the site(s), including location, configuration, and installation will be in accordance with the generic requirements of the Design Guidelines.

4.0 REPORTING

Information gathered as identified in previous sections will be compiled in a draft EIA report for study by the Review Committee.

APPENDIX B

Resumes of Previous Studies

WASTE AUDIT

EXECUTIVE SUMMARY

INTRODUCTION

Acadia Consultants & Inspectors Limited/ADI Limited was retained by the Westmorland/Albert Solid Waste Provisional Committee to conduct a "waste audit" of the region.

The waste audit is an assessment of the regions existing waste handling, collection and disposal networks, waste types and volumes and recycling operations. The waste audit would also include projections for population growth and waste generation over a twenty-five year period.

Study Area

The study area is composed of Westmorland and Albert counties.

Within these boundaries, there are 14 municipalities and 34 Local Service Districts (LSDs).

There are 12 municipally operated disposal sites within the study area, 5 sites operated by the NB Dept. of Transportation, one site operated by the NB Department of Supply and Services, and 3 private sites.

These solid waste disposal sites serve approximately 136 000 people in 47 000 households.

Methodology

Information related to the management of the regions solid waste was gathered from municipal officials who have input into their area's waste disposal facility.

Each of the waste disposal sites was visited and a site assessment completed. A site survey in the form of a site user questionnaire was carried out at some of the sites by the attendants. This survey identified types of waste, types of vehicles and type of haulers entering the sites.

Most of the commercial haulers along with a representative portion of the high volume generators received a follow-up interview.

The 23 operations that serve the study area through recycling of some material were surveyed. These range from a bottle exchange to an operation utilizing the material such as in the manufacture of kitty litter.

Previous solid waste reports on the areas disposal operations and applicable literature were also reviewed.

Description of Sites

None of the existing sites meets the environmental guidelines recently adopted by the Department of Municipal Affairs and Environment.

None have liners to contain leachate within the site and none have leachate treatment systems.

There are no surface water or ground water monitoring programs in place even though sixty-one percent have water nearby.

Open burning is carried out at fifty five percent of the sites.

Cover is applied at only four of the sites on a daily basis.

Only half of the sites have a full-time attendant.

Collection and Disposal Systems

Nine (9) of twelve (12) municipalities provide organized refuse collection services at an average annual cost of $24/household. In addition, 11 of 34 LSDs provide an organized collection service on a contract basis at an average annual cost of $45/household.

The collection cost to service all of the existing households in the region (excluding apartments) with an organized collection service is estimated to total $1,500,000 annually.

The disposal cost for the eighteen (18) public disposal sites in the study area is approximately $ 1 290 000 annually or $ 15 per tonne of waste generated.

The region's estimated waste management cost for household collection and disposal of all landfillable wastes is $2 790 000 annually. This represents approximately $60 per household annually or $20.50 per capita.

Collection of commercial/industrial solid waste is the responsibility of the generator.

Disposal of wastes that do not fall into the typical waste category that can be landfilled (example, hazardous, medical, etc.) is also undertaken by the generator under guidelines established by the Federal or Provincial Governments.

Survey Results

The total number of site users at the nine waste disposal sites surveyed was approximately 3 700 vehicles per week. The light pick-up truck (1/4 ton - 1/2 ton) accounted for

48% of all vehicles, and passenger cars represented 35% of the total leaving 17% for larger vehicles.

An analysis shows that although the majority of waste disposed of is hauled by vehicles having capacities equal to or greater than 9 cubic metres, they represent less than 7% of the vehicles actually entering the sites.

The number of sites make it appear convenient to go often and there are no deterrents (such as tipping fees) to reduce the number of vehicles entering the sites.

Twenty-one (21) commercial haulers in the region were interviewed. Their operations range in size from one operator with a half ton truck to more than a dozen employees using specially designed compactor units.

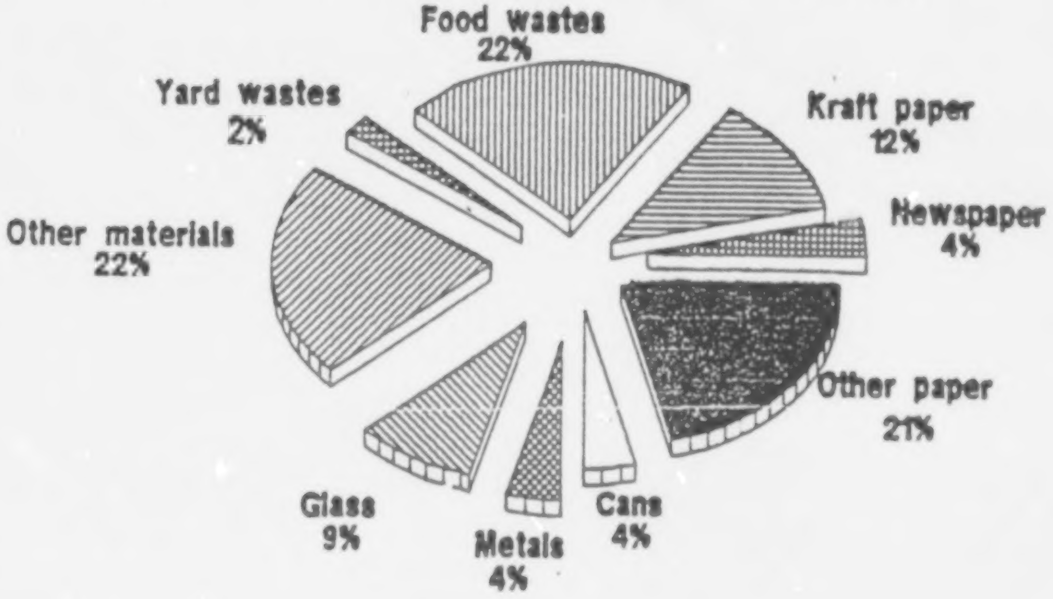
Typical Solid Waste Stream

The typical solid waste stream in the region is composed of refuse generated in our homes, schools, offices, institutions, retail establishments, small industries and construction sites.

The typical waste stream can be identified by generator or source, and the proportions for this region are estimated as follows:

Domestic	44%	Institutional	2%
Commercial	46%	Construction/Demolition	1%
Industrial	5%	Other	2%

The composition of the typical waste stream in the Atlantic Region has been found to consist of the approximate proportions shown in the figure below. This material can be accepted at a regional solid waste disposal facility.



COMPOSITION OF MUNICIPAL SOLID WASTE FOR THE ATLANTIC REGION

Annual waste quantities are normally predicted by using a waste generation rate per person and multiplying by the expected population. The following rates for the typical solid waste stream have been recommended for this region:

urban	2.1 kg/person/day	
		5.5 kg/household/day
	rural	2.2 kg/household/day

These rates are estimates of the typical solid waste stream and include commercial, industrial, institutional and construction wastes.

Using these figures, the 1989 total annual waste for disposal in a regional facility serving Westmorland and Albert Counties is estimated at 86 000 tonnes.

Other Wastes

In addition to the types of wastes in the "typical" solid waste stream, there are other types of waste material which may be of significance to the region. The provincial government is developing an integrated waste management plan where all wastes are categorized and different waste management strategies are outlined for the wastes. This document will be available to the public soon. Some wastes will require special methods of handling or disposal. They include:

Hazardous Wastes: These wastes would not be disposed of in the regional disposal facility. Disposal of these wastes will be the responsibility of the generator under guidelines established by the Federal and Provincial Governments.

Petroleum Wastes: Includes waste oil and contaminated soil. The Provincial Government is setting up a separate program and facilities to handle this waste.

Fish Offal: This waste will not be disposed of in the regional facility. The Provincial Government has established guidelines for disposal of these wastes.

Medical Wastes: It is expected that the hospitals will handle their medical waste internally through a program developed in conjunction with the Department of Health.

Septic and Sludge Wastes: The Greater Moncton Sewage Commission (GMSC) plant is expected to generate between 11 400 tonnes (at 32 percent solids) or 18 200 tonnes (at 20 percent solids) of sludge annually. Other waste will come from individual septic tanks and wastewater treatment plants. This waste could be disposed of in the regional facility if appropriate systems are put in place.

Agricultural Waste: The most serious agricultural waste problem is dead animals. A portion is being handled by the meat processors and by rendering companies. A "dead stock service" such as that in other provinces would help alleviate this problem.

Sawmills: Most of the bark, sawdust, wood chips and shavings produced are sold and none of the sawmill by-products are expected to go to the regional facility.

Meat Processing: Paunch manure, tail end screenings and barn cleanings are at present taken to the City of Moncton landfill. Most of this material could be more appropriately used as fertilizer than placed in the regional facility.

Recycling Operations

In total, 23 recycling operations were interviewed. Although some are located outside the study area, they all serve businesses in our area.

The materials presently being recycled in the region include bottles and glass, paper and cardboard, scrap metals, autos and white goods (refrigerators, stoves, washers, dryers), waste oil, used grease and animal remains.

Markets have been identified within New Brunswick for newsprint, cardboard, animal remains, glass, car bodies, white goods and waste oil.

Future Projections

In the next 25 years, the population in the area is predicted to increase to over 190 000 people.

The estimated waste generation by the year 2014 is expected to be 115 200 tonnes of waste annually.

WASTE MANAGEMENT ALTERNATIVES

EXECUTIVE SUMMARY

INTRODUCTION

In order for the Westmorland/Albert Solid Waste Provisional Committee to select the optimum waste system for the region, a general assessment and presentation of the various waste management alternatives from the technical, economical, and social perspectives was required.

Acadia Consultants & Inspectors Limited/ADI Limited was retained by the Committee to prepare a report of the waste management alternatives for the region.

EXISTING REGIONAL SITUATION

The study area is composed of Westmorland and Albert counties. The approximately 140 000 people in the area are at present served by 18 solid waste disposal sites.

The predicted waste generation for the region is expected to increase from 86 000 tonnes of waste in 1989 to 115 000 tonnes of waste in 2014.

Approximately 33 800 of the region's 47 000 households are served by a residential curbside collection service.

Commercial, industrial and institutional generators are served by commercial collection contractors or by their own forces.

Further background on the existing situation can be found in the "waste audit" previously completed by the Provisional Committee.

COST SHARING PLANS

Cost sharing for development of solid waste management facilities is promoted by both the Provincial and Federal governments.

The Province will provide funds for offsetting capital costs incurred in the implementation of a regional solid waste management strategy. Eligible capital cost items may benefit from up to 50 percent assistance. Further, if after provincial funding the tipping fee exceeds $40 per tonne, additional funding of up to 65 percent is available.

The Government of Canada's Development of Resource and Energy Conservation Technology Program provides cost-shared funds to seek new ways to recover or reduce the millions of tonnes of waste thrown away annually. It is not expected the federal program will apply to this region unless changes to the requirements are made.

TRANSPORTATION-TRANSFER SYSTEMS

Two types of costs are involved in the transportation of solid waste to a central disposal facility: collection and linehaul.

It is understood that the majority of the region will have a local organized collection system developed. This is necessary to provide an adequate level of service and to eliminate or reduce the cost of transfer stations.

To determine if linehaul costs were a significant factor in the overall solid waste costs for the region the costs for two regional facilities vs one facility were prepared.

Linehaul costs were developed based on distance from the centroid of the various zones in the region to the regional facility(s) located at the centroid of the area being served. Actual linehaul costs will depend on the final location of the facility.

Estimates of linehauls cost by direct haul with the collection vehicle (22 m^3 vehicle) are as follows:

1) a single landfill for the region total annual cost: $419 800 ($4.88/tonne)
2) an incinerator plus landfill for the region total annual cost: $569 000 ($4.88/tonne linehaul + $1.74/tonne for hauling from incinerator)
3) two landfills for the region total annual costs: $306 700 ($3.57/tonne)

Where linehaul with the collection vehicle increases collection costs and a more local assembly point is required for residents and business to bring their wastes there is potential that a transfer system and linehaul with a dedicated vehicle may become cost effective.

Urban transfer systems are not expected to be necessary or economical because of the anticipated proximity of the major urban areas to the disposal facility.

Typical rural transfer systems being operated in North America include: green box systems, drop box systems, and stationary compactor facilities.

Even though the region has a rail system in place, rail transfer of solid waste is not a viable option for the region due to the relatively small quantities and short distances involved.

A preliminary analysis suggests there is potential for transfer stations to serve the Alma, Cap Pelé, Elgin, Halls

Hill, Petitcodiac, Port Elgin, Riverside-Albert and Sackville zones if only one regional disposal facility is constructed. The capital cost of such a system are estimated at $686 000. Including the operation and maintenance cost and repayment of capital debt (after provincial funding is applied) the total annual cost will be $438 000.

Adding linehaul costs (combination of direct haul and with dedicated transfer vehicles) to the annual costs of the transfer system brings the total annual cost of transportation to $741 000 for single landfill disposal.

The cost of transportation with direct haul was found to be less than that of a system using transfer stations and direct haul.

DISPOSAL TECHNOLOGIES

The region will generate approximately 2.5 million tonnes of waste over the next 25 years. To dispose of this waste the 4 major technologies of composting, incineration, recycling and sanitary landfill (which are considered to be safe, economically feasible and environmentally acceptable) have been evaluated.

COMPOSTING

Composting is defined as a method of solid waste management whereby the organic component is biologically decomposed under controlled conditions to a state in which it can be handled, stored, and/or applied to the land without affecting the environment.

Composting can result in substantial improvements in properties of materials such as municipal solid waste or sewage sludge. It cannot treat noncompostable materials such as glass, plastic or metal; only organic materials can be composted.

In spite of its many important advantages, composting has been neither common nor successful in North America until recently because of past failures, complexity of the system required, odours, equipment failures, costs and disposing of the compost.

Backyard composting is increasingly recognized as one of the cheapest initiatives, ton for ton, that a municipality can take.

Centralized leaf and yard waste composting is now quite a common practice in the United States and could divert 10 percent of the region's residential waste.

The "Canadian Convertit Technology" process composts municipal solid waste into a valuable organic product for agricultural and horticultural use. DMAE has reviewed the system and does not feel there is sufficient technical data available to consider this method for the Westmorland/Albert region at this time.

Composting on a large scale would not be practical for the Westmorland/Albert Region at this time. However, backyard composting and leaf and yard waste composting could be incorporated into the initial recycling program for the region.

ENERGY-FROM-WASTE (EFW) SYSTEMS

With municipal refuse, during the incineration process the volume is generally reduced to approximately 10 percent of the original volume and the organic burnout is usually of the order of 95 percent or better.

Two incineration technologies were considered to be applicable to the Westmorland/Albert region: modular and mass burn.

A single unit of the modular type of equipment can now process over 100 tonnes per day. By paralleling multiple units, this incineration technology can be practical. The life span of these module units is estimated at 20 years. Typically up to 60 percent of the energy released in these units can be recovered in the form of steam or hot water.

The mass burn systems offer lower operating costs and higher heat recovery efficiencies. The mass burn systems are typified by a custom design for each application and are generally cost competitive in the 200 to 300 tonnes per day range. The heat recovery for these units is of the order of 70 percent or better through a waterwall boiler tube system. The useful life of units are normally in excess of 20 years.

Energy produced by incinerators can be recovered and transferred to steam, hot water or electricity. EFW plants usually fall within the following categories:

- incineration with steam production only,
- incineration with electric power production only,
- incineration with steam and electric power production (co-generation)

An EFW facility will reduce the need for landfilling; however, a landfill operation will be required for disposal of waste which cannot be incinerated, disposal of ash residue and disposal of waste when the incinerator is not operating.

An incinerator will reduce the volume of municipal solid waste by about 90% and its weight by 70%. The noncombustible fraction of typical municipal solid waste is approximately 15% of the total.

The combustible solid waste projections for Westmorland/Albert are 73 100 tonnes in 1989 and 97 750 tonnes in 2014 an increase of 33.7 percent over the 25 year period.

The energy recovered from incineration in 1989 would be equivalent to approximately 16 million litres of heavy fuel oil fired in a modern heating boiler. If all the heat available were directed to the production of electric power, an annual production of approximately 45 million kilowatt hours could be expected for sale.

There is insufficient potential for steam or hot water use from industrial or commercial operations in the region to warrant a dedicated EFW facility. However, a co-generation facility selling steam tc the institutional users at the Moncton & George Dumont Hospitals and Université de Moncton plus producing electricity for NB Power is an option.

Producing electricity alone for NB Power use is an option which has definite advantages in siting, loading of the facility and providing a single customer.

RECYCLING

By definition to recycle means to separate the mixed solid waste into its component parts and to process these materials in order to replace virgin feedstock in the manufacture of new products.

Recycling can save energy, water, other resources, and it also reduces pollution.

In order to reap the benefits of recycling the cumulative effect of many recycling initiatives is required.

Recycling requires the separation of waste into different materials and products, each coming from different sources and with its own particular handling and processing characteristics, markets and end uses. The fundamental objective of efficient recycling is to maximize both the volume of the material recovered and its quality.

Three basic recycling approaches have evolved:

- source separation of dry recyclables (which may be supplemented by limited composting programs) typified by curbside pickup and well known as the "blue box" program,
- wet/dry systems (more common in Europe) where householders have separate bins for "wet" garbage and dry wastes with wet materials composted,
- mixed solid waste systems where source separation is not required as separation can be done at a central facility giving end products of separated recyclables and usually refuse-derived fuel.

Diversion rates are not always calculated uniformly from region to region. Potential diversion rates range from 10-70 percent depending on the recycling program in the area.

The feasibility of recycling depends on markets for an end user has to be found. Separating and collecting recyclable wastes is not, by itself, recycling. Potential markets available for the Westmorland/Albert region include: newspaper, corrugated cardboard, glass, metals and plastics.

SANITARY LANDFILL

A sanitary landfill is a controlled access facility designed and constructed to protect the environment, public health and safety.

An integral part of a sanitary landfill is the environmental protection measures which are installed prior to the site going into operation and the on-going monitoring to ensure no negative environmental impacts.

Recently adopted standards require that facilities are properly lined with clay or a geomembrane material to contain the leachate generated and incorporate a leachate collection system.

Other design criteria which must be incorporated into the sanitary landfill include settling ponds, gas control, site access roads, and a site operation plan.

To service the region, the minimum site area required is estimated at 55 hectares for a single landfill. It would be developed in phases sufficient for a 4-6 year period.

OTHER TECHNOLOGIES

Other technologies that are associated with landfilling are: baling and shredding. These operations reduce the landfill volume required for disposal of the regions waste. However, for this region the disadvantages outweigh the advantages as each system adds a significant cost.

OPTION COMPARISON

All options presented require a landfill operation although the size will vary with each technology. Landfill will not significantly reduce waste volumes. All options would be constructed and operated utilizing the best available technology (BAT). Therefore, from a technical point of view each option is environmentally acceptable.

Recycling by itself is commendable; but, to achieve significant results in quantity reduction prior to disposal requires much more than a source separation program.

Complete resource recovery systems are quite probably the best solution to the solid waste problem. However, because of size limitations, markets and cost they may not be adaptable to this region at this time.

EFW plants significantly reduce volumes and do recover useful energy from waste.

COSTS ASSOCIATED WITH DISPOSAL TECHNOLOGIES

The estimates provided are preliminary and are based on published information and other data from our files on similar systems or projects.

1) INCINERATION

The incinerator design capacity is established at 315 tpd. The associated landfill is designed to receive 46 500 tpa of unprocessable waste and ash.

A detailed analysis has been done on two options:

option 1: an EFW electrical generation plant which would produce electric power for sale to N.B. Power.

option 2: an energy from waste co-generation plant which would supply steam to three institutions in the Hall's creek area, and sell the balance of energy as electric power to N.B. Power.

Revenues from the sale of electricity have been calculated at a rate of 6 cents per kilowatt hour. It is believed that this is the maximum sales value at this time.

Initial (year 1) Costs associated with the incineration plants without any government assistance are summarized as follows:

	Option 2 Electricity Only	Option 2 Co-Generation
Capital cost EFW only	$ 38 000 000	$40 000 000
Processing Cost EFW only	$64.88/tonne	$68.72/tonne
Associated landfill cost year one	$4 200 000	$ 4 200 000
Processing cost associated landfill	$20.73/tonne	$20.73/tonne

The landfill will require expansion in 5 year phases at additional cost. Landfill equipment will have to be replaced at midlife of the incinerator.

2) RECYCLING

It is recommended that the Westmorland/Albert region choose initially to go with a conventional source separation strategy.

The "Commission Managed" recycling program would initially be composed of five components: a curbside recyclables collection, drop-off recycling centres, backyard composting, centralized leaf and yard waste composting and a commercial recycling program.

It is estimated that this program would divert 13 880 tonnes or 16% of the total annual waste.

The projected costs and revenues for the programs are as follows: $2 052 000 in capital costs, $479 600 in annual operating costs, $ 208 900 in annual revenues, and $207 700 in avoided disposal costs.

The total annual cost of the program without government assistance will be $558 000. The net cost per tonne of waste diverted is $40.20.

Although the recycling component does not initially divert a large percentage of the regions waste, the program can be expanded. The implementation of the recycling program is a necessity to offset the increase in generation rates that has occurred in past years.

3) SANITARY LANDFILL

A landfill requires an initial capital expenditure as well as phased capital expenditures for development, closure and replacement of equipment.

Initial (year 1) costs associated with the landfill(s) option without any government assistance programs are summarized as follows:

	Single Landfill Facility	Two Landfill Facilities
Capital cost	$ 5 420 000	$ 7 536 000
Operation & Maintenance	822 000	1 147 000
Processing Cost	$ 26.60/tonne	$ 37.00/tonne

Landfill operating costs include three main factors, manpower, site operation which provides for daily cover, equipment operating and repair and the environmental monitoring program.

COMPARISON OF OPTION COSTS

A true cost comparison between the options can be made by summarizing the present worth of the capital and operating costs over the expected operational life of the facilities (25 years) and then calculate a "levelized" cost per tonne disposed of for each option. This comparison is unaffected by the provincial grant that is available. The complete information is shown in Table 7.11 on page 7.32.

The Incineration option has the highest present worth cost.

The least cost option is the Single Landfill.

Only two options, Incineration and Recycling generate revenue.

The levelized cost per tonne is as follows:

single landfill - $25.81
two landfills - $33.69
incineration (revenue @ 6¢per kwh) - $69.50
initial recycling program - $48.00

For incineration projects the Province will fund up to 65% of the capital costs. For this project, the Provincial capital assistance is calculated at $24 400 000, a 58% contribution level. The regional tipping fee is calculated at $40/tonne.

A sensitivity analysis has been included for the incineration option to show the effect of varying power rates. At a sale value of 12¢ per kwh the levelized cost would be $34.07/tonne. The regional tipping fee would be $18.87/tonne with the Provincial capital assistance at $21 100 000 a 50% contribution level.

For a sanitary landfill the Province will fund up to 50 percent of the total capital costs. For this project the Provincial capital assistance is calculated at $2 163 000, a 39.9% contribution level, for one facility and $3 768 000, a 50% contribution level, for two facilities. The regional tipping fee is calculated at $19.78/tonne and $25.16/tonne respectively.

The inclusion of the suggested recycling program will add $2.23/tonne to the tipping fee of the single landfill. There will be no change in tipping fee for the incineration option because of the effect of the Provincial Grant which maintains the figure at $40 per tonne.

IMPLEMENTATION OF ALTERNATIVES

In order to select a Waste Management Strategy for the Westmorland/Albert Region, the Waste Audit and the Waste Management Alternatives Studies will be publicized and be the subject of the discussions in the Region over the next few months. After receiving feedback from the Public, the Provisional Committee will select a Strategy for the Region which will probably include a combination of the Alternatives discussed herein.

To implement the chosen alternatives, the Provisional Committee must then develop a site selection and evaluation process that will identify potential sites and ultimately select the most suitable site(s).

There are three major steps in site selection: identification of potential sites, individual site investigation, and selection and testing of the recommended site.

The main considerations that must be addressed in the identification of potential sites are: land availability, social implications, legal, economic impacts, accessibility, physical and, ranking with respect to other potential sites.

Firstly, areas must be eliminated objectively and without bias. Then potential sites are identified from areas that were not eliminated.

Each individual site determined from the preliminary evaluation would be scored based on selected criteria being applied. The sites will then be evaluated for the overall waste management plan and for individual development. The recommended site should then be presented to the public for review and comment.

After public review and comment and selection of the site, a concept design would be completed and a series of subsurface observation wells would be installed for monitoring.

Finally, a comprehensive geotechnical and hydrogeological evaluation would be completed prior to a final design being commenced.

The Provincial regulations require that an environmental impact assessment be carried out on all solid waste disposal waste facilities. This assessment adresses all the major issues and impacts that such a facility will have on the people from an environmental and socio-economic standpoint.

APPENDIX C

Boring Logs

ROUTE 126 SITE

WESTMORLAND/ALBERT SOLID WASTE

PROVISIONAL COMMITTEE

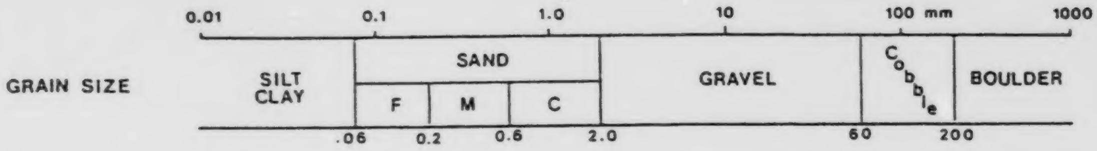
BOREHOLE LOGS

TEST PIT LOGS

GRAIN SIZE ANALYSES

DESCRIPTIVE TERMS - BORING LOGS

SOILS



COMPACTNESS gravel, sand, tills

N,RANGE	0 - 4	4 - 10	10 - 30	30 - 50	>50
DENSITY	V. LOOSE	LOOSE	MEDIUM	DENSE	V. DENSE

CONSISTENCY silt, clay

S,KPa	<12.5	12.5 - 25	25 - 50	50 - 100	100 - 200
CONSISTENCY	V. SOFT	SOFT	MEDIUM	STIFF	V. STIFF

ROCK

RQD	OVERALL QUALITY
0 - 25	VERY POOR
25 - 50	POOR
50 - 75	FAIR
75 - 90	GOOD
90 - 100	EXCELLENT

FRACTURE SPACING

<50 mm VERY CLOSE
50 - 300 mm CLOSE
0.3 - 1 m MODERATE
1 - 3 m WIDE
>3m VERY WIDE

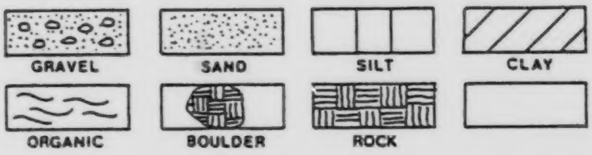
COMP. STR. MPa	0.85 - 3.5	3.5 - 14	14 - 55	55 - 220	>220
DESCRIPTION	V. WEAK	WEAK	MODERATE	STRONG	V. STRONG

SAMPLE TYPES (location to scale on log)

S	SPLIT TUBE
T	SHELBY TUBE
P	PISTON
F	AUGER
W	WASH
G	SHOVEL
H	CARVED BLOCK
K	SLOTTED
V	IN SITU VANE
NR	NO RECOVERY

ROCK CORES A(30mm); B(41mm); N(54mm)

LOG SYMBOLS



NOTATION AND SYMBOLS

N — standard penetration test; blows by 475 J drop hammer to advance Std. 50 mm O.D. split tube sampler 0.3 m

RQD — per cent of core consisting of hard, sound pieces in excess of 100 mm long (excluding machine breaks)

RECOVERY — sample recovery expressed as per cent or length

S — shear strength, kPa; vane ▼ ; penetrometer ■ ; unconfined ●
Sr — shear strength, remoulded; vane ▽ ; penetrometer □ ; unconfined O
Dd — dry density; t/m^3
W — natural moisture content, per cent X
PL — plastic limit, per cent ⊢—
LL — liquid limit, per cent —⊣
Groundwater Level ▼ ; seepage ▽

Form 261 0190

Acadia Consultants and Inspectors Limited

LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	401
LOCATION:	Route 126	**PAGE:**	1 of 2
GROUND SFC. ELEV.:	118.42 m **DATUM:** NBGIC	**DATE:**	November 28, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	14"	1 for 12 2, 11			Grey to brown, silty sand, some organics	118.42	
							Clayey silty SAND, some gravel, and pieces of sandstone, reddish brown, compact (TILL) SM-SC	118.1	
1									
2	2	S	15"	3, 13 15, 15	28				
								*	▼
3	3	S	13"	6, 8 18, 21	26 for 2"		Liquid Limit 16% Plastic Limit 10% Moisture Content 11%		
							SANDSTONE, dark reddish brown, moderately weathered	114.8	
4									
5	4	NQ	4½'/5'	5 for 0 RQD= 21/60					
6							MUDSTONE, reddish brown, soft, weakly cemented, with green calcareous deposits	112.6	
7	5	NQ	100%	47½/120					
8								110.4	

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	401
LOCATION:	Route 126	**PAGE:**	2 of 2
GROUND SFC. ELEV.:	118.42 m **DATUM:** NBGIC	**DATE:**	November 28, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Mudstone, as above	110.4	
							SILTSTONE, reddish brown, closely fractured	110.0	
9									
							Dark grey SANDSTONE, grading to grey CONGLOMERATE at 10.4 m, fractures spaced at greater than 280 mm	109.1	
10	6	NQ	100%	RQD= 57/60					
							End of borehole * Piezometric water level noted in piezometer sealed in the bedrock.	107.6	
11									
12									
13									
14									
15									

Acadia Consultants and Inspectors Limited

LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	402
LOCATION:	Route 126	PAGE:	1 of 2
GROUND SFC. ELEV.:	121.90 m DATUM: NBGIC	DATE:	November 28, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								121.90	
	1	S	13"	1 2 3 6	5		Organics	121.7	
							Grey to brown silty sand	121.4	
1							Clayey silty SAND, with gravel, reddish brown, compact to dense (TILL)		
	2	S	2"	9 9 13 20	22 for	4		*	▼
2									
3									
	3	S	12	12 11 16	27				
								118.1	
4							MUDSTONE, reddish brown, soft, highly weathered, with oxidation and calcareous deposits throughout		
	4	S		30 for 6"					
5									
	5	NQ	100%	RQD= 33/60					
6									
	6	NQ	100%	RQD= 47/72					
7									
8								113.9	

Acadia Consultants and Inspectors Limited

LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	402
LOCATION:	Route 126	PAGE:	2 of 2
GROUND SFC. ELEV.:	121.90 m DATUM: NBGIC	DATE:	November 28, 1990

DEPTH m	SAMPLE			Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8								113.9	
	7	NQ	100%	RQD= 84/108			Mudstone, as above		
9									
10									
							End of borehole * Piezometric water level noted in piezometer sealed in the bedrock.	110.9	
11									
12									
13									
14									
15									

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	403
LOCATION:	Route 126	PAGE:	1 of 2
GROUND SFC. ELEV.: 120.14 m	DATUM: NBGIC	DATE:	November 29, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								120.14	
	1	S	14"	1 1 2 6	3		Organics	120.0	
							Grey to brown silty sand	119.8	
1							Sandy silty clay , trace of gravel, reddish brown, compact (TILL) CL Liquid Limit 20% Plastic Limit 10% Moisture Content 12%		
2	2	S	12"	5 10 14 20	24				
								*	▼
3	3	S	9"	8 20			Boulder		
4									
5	4	NQ	3.25'/5'	RQD= 21/60					
							Brown, fine grained SANDSTONE, top 460 mm highly weathered becoming slightly weathered below this depth, fracture spacing greater than 100 mm.	114.8	
6									
7	5	NQ	100%	RQD= 99/120					
8								112.1	

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	403
LOCATION:	Route 126	**PAGE:**	2 of 2
GROUND SFC. ELEV.:	120.14 m **DATUM:** NBGIC	**DATE:**	November 29, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Sandstone, as above	112.1	
9							Grades to mudstone from 8.2 to 8.8 meters		
10	6	NQ	100%	RQD= 48/60			Vertical fracture from 9.6 m to 10.1m (Lost return)		
11							End of borehole	109.2	
12							* Piezometric water level noted in piezometer sealed in the bedrock.		
13									
14									
15									

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	404
LOCATION:	Route 126	**PAGE:**	1 of 2
GROUND SFC. ELEV.:	95.70 m **DATUM:** NBGIC	**DATE:**	December 3, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								95.70	
	1	S	17"	10 20 10 14	30		Brown, sand & gravel, with sandstone cobble, some organics (Roots)		
							SANDSTONE, highly weathered, brown, fine to medium grained, fractures very closely spaced	95.1	
1									
	2	S	6"	30 for 6"					
2									
3									
	3	S	15"	6 8 23	31			*	▼
4									
	4	S		11 blows for 0"					
5	5	NQ	4½'/5'	RQD= 17/60					
6									
	6	NQ	100%	RQD= 53/120					
7							At 7.8 m the sandstone became moderately weathered and grey in color		
8								87.7	

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LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.:	2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING:	404
LOCATION: Route 126		PAGE:	2 of 2
GROUND SFC. ELEV.: 95.70 m	DATUM: NBGIC	DATE:	December 3, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Sandstone, as above	87.7	
9							Brown clay on some fracture surfaces below 9.9 m		
10	7	NQ	100%	RQD= 18/60					
							End of borehole * Piezometric water level noted in piezometer sealed in the bedrock.	84.9	
11									
12									
13									
14									
15									

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	405
LOCATION:	Route 126	**PAGE:**	1 of 2
GROUND SFC. ELEV.:	100.96 m **DATUM:** NBGIC	**DATE:**	December 3, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								100.96	
							Organics	100.8	
	1	S	16"	1 for 12 4 6	5		Brown sand & gravel, some organics	100.7	
1							Clayey silty SAND, some gravel, reddish brown, compact (TILL)		▼
2	2	S	15"	8 9 12 12	21				
3	3	S	11"	9 16 10 10	26 for 0"				
4							MUDSTONE, highly weathered to residual soil	97.3	
	4	S		30 for 2"					
5							SANDSTONE, dark brown, fine to medium grained, moderately weathered, becomes light brown at 6.6 m and coarse grained 7.2 m to 7.5 m	96.3	
6	5	NQ	48"/60"	RQD= 37/60					
7	6	NQ	100%	RQD= 34/108					
							MUDSTONE, brown, soft, weakly cemented	93.3	
8								93.0	

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	405
LOCATION:	Route 126	**PAGE:**	2 of 2
GROUND SFC. ELEV.:	100.96 **DATUM:** NBGIC	**DATE:**	December 3, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Mudstone, as above	93.0	
9									
							SILTSTONE, dark brown, fairly soft	91.7	
10	7	NQ	100%	RQD= 62/72					
11							End of borehole	90.0	
12									
13									
14									
15									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING: T.P. #1
LOCATION: Route 126		PAGE: 1 of 1
GROUND SFC. ELEV.: 120.12 m	DATUM: NBGIC	DATE: November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								120.12	
							Organics		
								119.7	
							Grey silty sand		
								119.3	
1							Clayey silty SAND, with gravel, reddish brown, compact (TILL)		
2									
3								117.0	
							Sandstone		
								116.6	
	1	G					Mudstone/siltstone, dark reddish brown		
4								116.1	
							End of test pit		
5									
							NOTE: Swampy area at surface		
6									
7									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #2
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 124.44 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								124.44	
							Organics	124.2	
							Brown, silty SAND		
1								123.4	
							Clayey silty SAND, with gravel, reddish brown, compact (TILL)		
2								122.0	
	2	G					Red sandstone, poorly cemented		
3	3	G						121.3	
							conglomerate, light grey	121.1	
							SANDSTONE, fine to medium grained, dark reddish brown		∇
4	4	G							
								119.6	
							Bottom of test pit 4.8 m		
5									
6							NOTE: Water at 3.8 m		
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING: T.P. #3
LOCATION: Route 126		PAGE: 1 of 1
GROUND SFC. ELEV.: 121.72 m	DATUM: NBGIC	DATE: November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	121.72	
							Silty SAND, grey to brown	121.4	
1							Clayey silty SAND, with gravel, reddish brown, compact (TILL)	120.7	
2									∇
							Mudstone/siltstone reddish brown	119.3	
3							Conglomerate, light grey	119.1	
4 5 6 7 8							Bottom of test pit 3.8 m NOTE: Water seepage at 2.3 m	117.9	

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #4
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 124.89 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								124.89	
							Organics	124.8	
							Grey silty SAND	124.2	
1							Clayey silty SAND, with gravel, reddish brown, compact, with pieces of sandstone (TILL)		
2									
3								121.2	
4							Mudstone, highly weathered to residual soil, reddish brown and grey		
5								119.7	
							Bottom of test pit 5.2 m		
6							NOTE: No water encountered		
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #5
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.:	123.68 m DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	123.68	
							Silty SAND, grey to brown	123.5	
1							Clayey silty SAND, with gravel, reddish brown, compact (TILL)	122.9	
2									
3							Red sandstone	121.0	∇
4							Bottom of test pit 3.8 m	119.9	
5									
6							NOTE: Water at 2.7 m Extremely heavy flow		
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #6
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 120.86 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								120.86	
							Organics	120.8	
							Brown sandy silt	120.3	
1							Clayey silty SAND, with gravel, reddish brown, compact (TILL)		
2								118.4	
							Grey/green sandstone	118.2	
3							Red sandstone – with interbedded mudstone	117.6	
4							Bottom of test pit 3.3 m		
5							NOTE: No water encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #7
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.:	129.83 m DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	TYPE	RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	129.83	
							Silty SAND, with gravel, reddish brown, compact (TILL)	129.7	
1									
							Clayey silty SAND, with gravel, reddish brown, compact (TILL)	128.7	
2									
							Grey sandstone	127.2	
3									
							Bottom of test pit 3.2 m	126.6	
4									
5							NOTE: No water encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #8
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.:	128.05 m DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								128.05	
							Organics	128.0	
							Silty SAND, grey to brown	127.2	
1							Clayey silty SAND, with gravel, reddish brown, compact (TILL)	126.1	
2							SANDSTONE, greenish grey		
3									
4								123.7	
							Bottom of test pit 4.4 m		
5									
							NOTE: No water encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #9
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 125.13 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	125.13	
							Silty SAND, brown	124.9	
1							Clayey silty SAND, some gravel, reddish brown, compact (TILL)	124.4	
2	5	G					SANDSTONE, medium grained, yellowish brown	122.9	
							Bottom of test pit 2.5 m	122.6	
3									
4									
5							NOTE: No water encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #10
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 122.79 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								122.79	
							Clayey silty sand, with gravel	122.7	
1							Clayey silty SAND, some gravel, reddish brown, compact (TILL)		
								121.0	
2							SANDSTONE, medium grained, yellowish brown		
								119.8	
3							Red sandstone		
								119.2	
4							Bottom of test pit 3.6 m		
5							NOTE: No water encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #11
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 121.35 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	121.35	
							Sandy silty clay with small stones	121.2	
							Clayey silty SAND, some gravel and pieces of sandstone, reddish brown, compact (TILL)	121.0	
1									
2									
3									
							Grey sandstone	118.2	
		–					Red sandstone	117.9	
4								117.5	
							Bottom of test pit 3.9 m		
5									
							NOTE: No Water encountered		
6									
7									
8									

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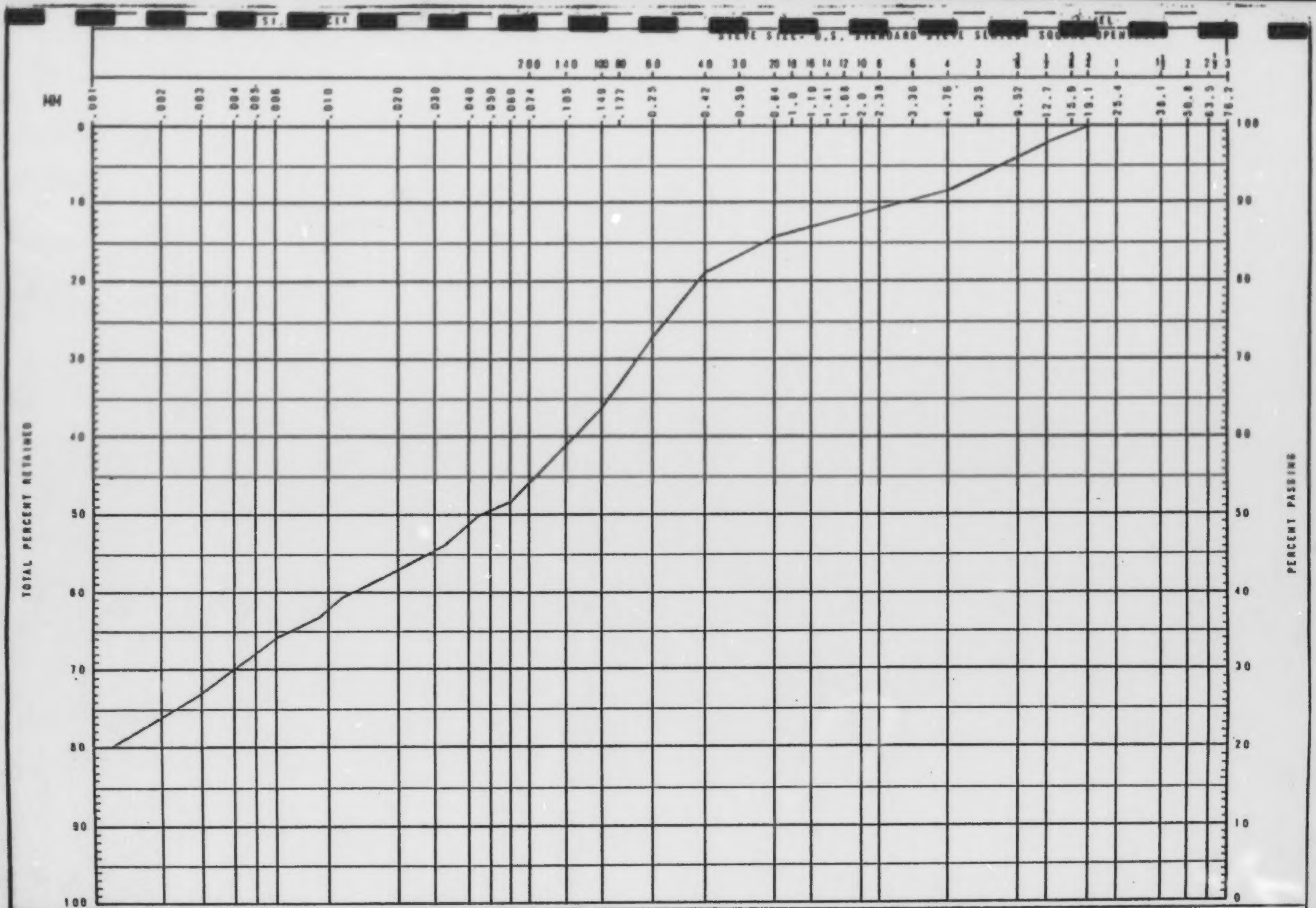
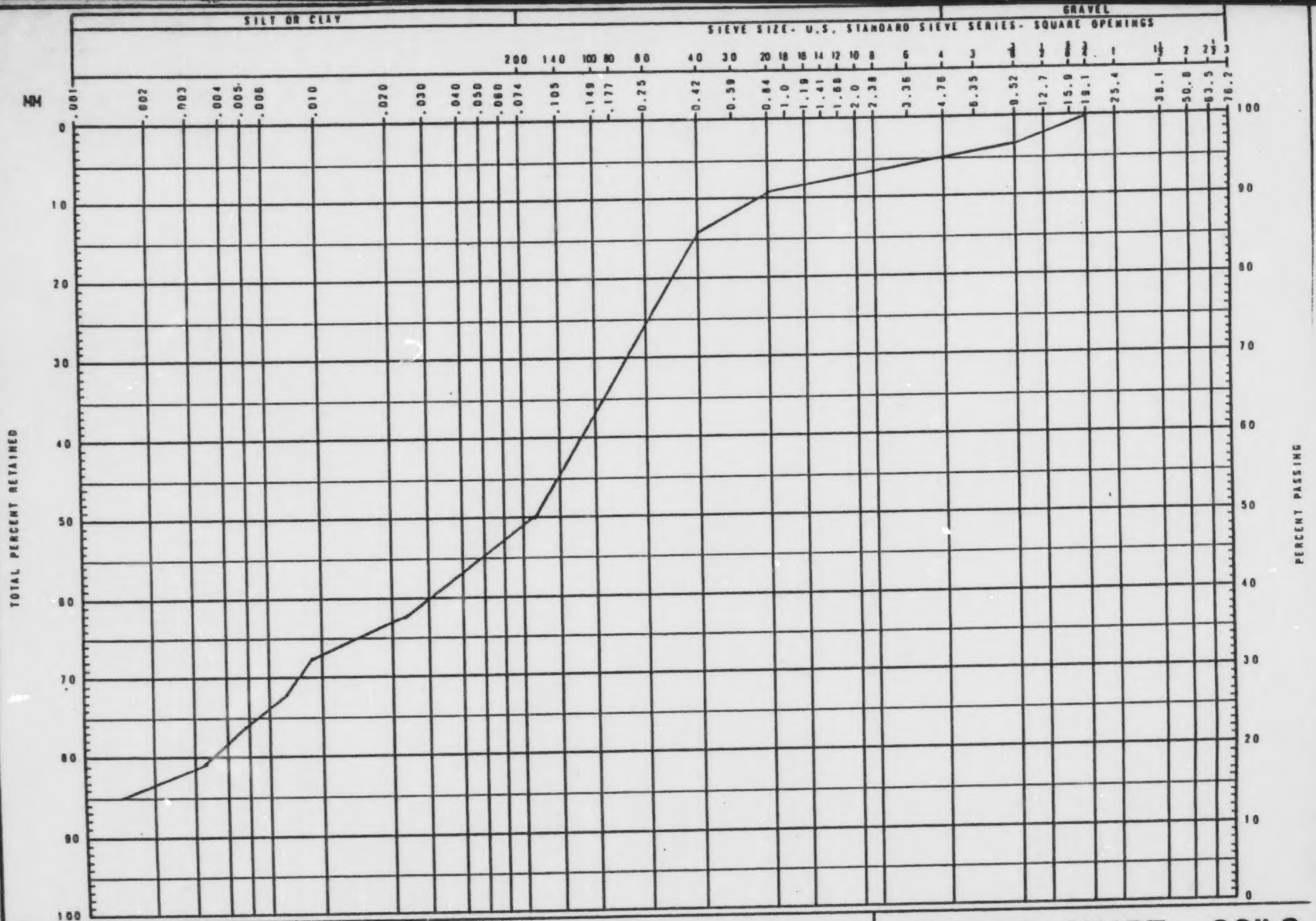
SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #12
LOCATION:	Route 126	PAGE:	1 of 1
GROUND SFC. ELEV.: 121.39 m	DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								121.39	
							Organics		
								121.3	
							Red clayey silty sand		
								120.7	
1							Clayey silty SAND, some gravel, reddish brown, compact with pieces of sandstone (TILL)		
2									
3									
								117.7	
							Red sandstone		
								117.6	
4							Bottom of test pit 3.8 m		
5									
6							NOTE: No Water encountered		
7									
8									



DESCRIPTION AND LOCATION:	CLIENT: WESTMORLAND/ALBERT SOLID WASTE	**GRADING CHART - SOILS**
BH 403 Sample 2 Sandy silty CLAY, some gravel.	PROJECT: RTE 126 SITE	Acadia Consultants and Inspectors Limited
	JOB NO: 2771-4.1	



DESCRIPTION AND LOCATION:
BH. 401 Sample 3
Clayey silty SAND, trace of gravel SM-SC

CLIENT: WESTMORLAND/ALBERT SOLID WASTE
PROJECT: RTE 126 SITE
JOB NO: 2771 - 4.1

GRADING CHART - SOILS

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DELONG DRIVE SITE

WESTMORLAND/ALBERT SOLID WASTE
PROVISIONAL COMMITTEE

BOREHOLE LOGS

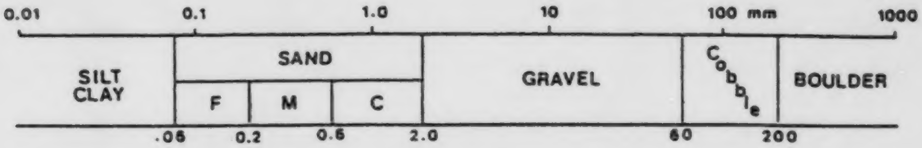
TEST PIT LOGS

GRAIN SIZE ANALYSES

DESCRIPTIVE TERMS - BORING LOGS

SOILS

GRAIN SIZE



COMPACTNESS
gravel, sand,
tills

N,RANGE	0 - 4	4 - 10	10 - 30	30 - 50	>50
DENSITY	V. LOOSE	LOOSE	MEDIUM	DENSE	V. DENSE

CONSISTENCY
silt, clay

S,KPa	<12.5	12.5 - 25	25 - 50	50 - 100	100 - 200
CONSISTENCY	V. SOFT	SOFT	MEDIUM	STIFF	V. STIFF

ROCK

RQD	OVERALL QUALITY	FRACTURE SPACING
0 - 25	VERY POOR	<50 mm VERY CLOSE
25 - 50	POOR	50 - 300 mm CLOSE
50 - 75	FAIR	0.3 - 1 m MODERATE
75 - 90	GOOD	1 - 3 m WIDE
90 - 100	EXCELLENT	>3m VERY WIDE

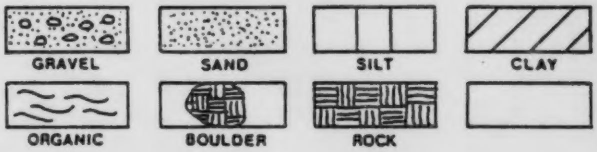
COMP. STR. MPa	0.85 - 3.5	3.5 - 14	14 - 55	55 - 220	>220
DESCRIPTION	V. WEAK	WEAK	MODERATE	STRONG	V. STRONG

SAMPLE TYPES (location to scale on log)

S	SPLIT TUBE	G	SHOVEL
T	SHELBY TUBE	H	CARVED BLOCK
P	PISTON	K	SLOTTED
F	AUGER	V	IN SITU VANE
W	WASH	NR	NO RECOVERY

ROCK CORES A(30mm); B(41mm); N(54mm)

LOG SYMBOLS



NOTATION AND SYMBOLS

N — standard penetration test; blows by 475 J drop hammer to advance Std. 50 mm O.D. split tube sampler 0.3 m

RQD — per cent of core consisting of hard, sound pieces in excess of 100 mm long (excluding machine breaks)

RECOVERY — sample recovery expressed as per cent or length

S — shear strength, kPa; vane ▼ ; penetrometer ■ ; unconfined ●
Sr — shear strength, remoulded; vane ▽ ; penetrometer □ ; unconfined O
Dd — dry density; t/m^3
W — natural moisture content, per cent X
PL — plastic limit, per cent ⊢——
LL — liquid limit, per cent ——⊣
Groundwater Level ▼ ; seepage ▽

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 101
LOCATION:	Delong Drive	PAGE:	1 of 2
GROUND SFC. ELEV.:	55.87 m DATUM: NBGIC	DATE:	October 22, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0			17"	1 for 12"			Organics	55.87	
	1	SS		2, 7	3		Grey silty clayey sand	55.7	
							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC	55.6	
1									
	2	SS	10"	6, 6 11, 15	17				
2									
3	3	SS	9"	11, 15 24, 21	39		Till, as above		
4									
	4	SS	10"	5, 23 30	53				
5							Till, as above Liquid Limit 20% Plastic Limit 14% Moisture Content 9%		
6	5	SS	14"	9, 22 35	57				▽
7									
	6	SS		7, 24 34	58				
8								47.9	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:** 2771-4.1
PROJECT: New Solid Waste Landfill Site	**BORING:** B.H. #101
LOCATION: Delong Drive	**PAGE:** 2 of 2
GROUND SFC. ELEV.: 55.87 m **DATUM:** NBGIC	**DATE:** October 22, 1990

DEPTH m	SAMPLE			Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8							Till, as above	47.9	
9							Mudstone, brown, soft poorly cemented, highly weathered	46.9	
	7	SS		44,50 for 3"					
10									
	8	NQ	32/36						
11									
	9	NQ	100%						
12							Sandstone	43.9	
							Bottom of bore hole	43.4	
13									

Acadia Consultants and Inspectors Limited

SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. #102
LOCATION:	Delong Drive	PAGE:	1 of 2
GROUND SFC. ELEV.: 55.41 m	DATUM: NBGIC	DATE:	October 23, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								55.41	
	1	SS	17"	1 for 12"			Organics	55.2	▽
				2, 6	3		Grey silty clayey sand	55.1	
							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC		
1									
	2	SS	10"	6, 8 10, 12	18		Liquid Limit 18% Plastic Limit 14% Moisture Content 11%		
2									
3									
	3	SS	9"	8, 15 22, 25	37				
4									
	4	SS	12"	11, 14 24	38				
5									
6								49.4	
	5	SS	4"	37 for 6"			Mudstone, residual soil, brown		
7								48.4	
	6	NQ					Mudstone, brown, soft, poorly cemented		
8								47.4	

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	B.H. #102
LOCATION:	Delong Drive	**PAGE:**	2 of 2
GROUND SFC. ELEV.:	55.41 m **DATUM:** NBGIC	**DATE:**	October 23, 1990

DEPTH m	SAMPLE				N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8							Mudstone	47.4	
	7	NQ							
							Bottom of borehole	46.9	
9							* Water encountered flowing along surface of till.		
10									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. #103
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 56.91 m	DATUM: NBGIC	DATE:	October 25, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
								56.91	
0	1	S	12"	1 for 12" 5, 14	6		Organics		
							Grey silty clayey sand	56.7	
							Clayey silty SAND, some gravel, compact, dark reddish brown (TILL) SM-SC	56.6*	▽
1									
2	2	S	9"	6, 8 10, 27	18		* Water flowing along surface of the till.		
3	3	S	8"	6, 12 18, 30	30				
4									
	4	S	6"	6, 22 All for 4"			Mudstone, residual soil, brown, very dense	52.3	
5									
6	5	S		39 for 4"					
							Mudstone grading to sandstone, brown	50.5	
7	6	NQ							
							Bottom of borehole 7.9 m	49.0	
8									

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SOILS LOG

X

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 104
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.:	57.63 m DATUM: NBGIC	DATE:	October 26,1990

DEPTH m	SAMPLE No.	TYPE	RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	10"	1, 1 2, 4	3		Organics	57.63	
							Grey silty clayey sand	57.4	
							Clayey silty,SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC	57.3	
1									
2	2	S	7"	6, 9 10, 15	19				
3	3	S	10"	8, 11 22	33				
4									
5	4	S	10"	8, 15 31 for 4"					
							Mudstone, brown, with sandstone seam at 6.5 m depth	52.1	▼
6									
7	5	NQ	100%						
8							Bottom of borehole 7.9 m	49.7	

Acadia Consultants and Inspectors Limited

SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 105
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 56.34 m	DATUM: NBGIC	DATE:	October 26, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	16"	1 for 12" 4, 5	5		Organics	56.34	
							Grey silty clayey sand	56.1	
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (TILL) SM-SC	55.8	
1									
	2	S	9"	5, 14 13, 15	27				
2									
3	3	S	12"	11, 17 15, 24	32		Till, as above		
4									▼
	4	S	12"	12, 16 25, 35	41				
5									
6									
	5	S		10 for no advance			Sandstone, fine grained brown	50.1	
7	6	NQ							
8							Bottom of borehole 7.9 m	48.4	

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 106
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 48.59 m	DATUM: NBGIC	DATE:	October 29, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	20"	1 for 12" 3, 5	4		Organics	48.59	
							Grey silty clayey sand	48.4	
							Clayey silty, SAND, some gravel, brown, compact (TILL) SM-SC	48.3	
1									▼
	2	S	10"	5, 10 12, 19	22				
2									
3	3	S	13"	7, 12 12, 25	24				
4									
	4	S	6"	12, 27 for 2"			Siltstone to fine grained sandstone, brown, slightly weathered	43.8	
5									
6	5	NQ	100%						
7							Bottom of borehole	41.3	
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		**JOB No.:**	2771-4.1
PROJECT: New Solid Waste Landfill Site		**BORING:**	B.H. #107
LOCATION: Delong Drive		**PAGE:**	1 of 1
GROUND SFC. ELEV.: 52.04 m	**DATUM:** NBGIC	**DATE:**	October 30, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	18"	1 for 12"	2		Organics	52.04	
				1, 3			Grey silty clayey sand	51.8	∇
							Clayey silty SAND, with gravel, dark reddish brown, compact to very dense (TILL) SM-SC	51.7*	
1									
2	2	S	8"	4, 9 9, 13	18				
3	3	S	10"	18, 28 46	74		Till, as above		
4							Mudstone, brown, highly weathered becoming moderately weathered with depth	47.8	
	4	S	8"	10, 56					
5	5	NQ	100%	RQD= 50%					
6							Bottom of borehole * Water flowing along surface of till.	45.6	
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 108
LOCATION:	Delong Drive	PAGE:	1 of 2
GROUND SFC. ELEV.: 44.15 m	DATUM: NBGIC	DATE:	October 31, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0			16"	1 for 12"			Organics	44.15	
	1	S		3, 7	4		Grey silty clayey sand	44.0	∇
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (TILL) SM-SC	43.9	
1									
	2	S	8"	3, 5 7, 17	12				
2									
3	3	S	16"	19, 27 25	52		Till, as above		
4									
5	4	S	11"	12, 20 41	61				
6	5	S	9"	37, 45 for 3"			Mudstone, highly weathered brown	38.1	
7	6	NQ	100%	43"/60" RQD			Sandstone, fine to medium grained, light brown, slightly weathered	37.2	
8								36.2	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.
PROJECT: New Solid Waste Landfill Site	BORING: B.H. #108
LOCATION: Delong Drive.	PAGE: 2 of 2
GROUND SFC. ELEV.: 44.15 m DATUM: NBGIC	DATE: October 31, 1990

DEPTH	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Sandstone, as above	36.2	
9	7	NQ	57"/60"	RQD= 44"/60"					
10									
	8	NQ	100%	RQD= 41"/60"					
11									
12	9	NQ	51"/60	RQD= 29"/60"					
							End of borehole * Water flowing along surface of till.	31.4	
13									
14									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 109
LOCATION:	Delong Drive	PAGE:	1 of 2
GROUND SFC. ELEV.:	43.88 m DATUM: NBGIC	DATE:	October 31, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	43.88	
	1	S	15"	1 for 12" 3, 5	4		Grey silty clayey sand	43.7 43.6	
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (TILL) SM-SC		
1									
2	2	S	12"	6, 7 6, 10	13				
3	3	S	7"	7, 14 22, 21	36				
4							Till, as above		
5	4	S	10"	13, 16 20 for 2"			Cobble		
6	5	S	10"	13, 19 25	44		Boulders	37.3	
7							Mudstone, brown		
8								35.9	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:** 2771-4.
PROJECT: New Solid Waste Landfill Site	**BORING:** B.H. #109
LOCATION: Delong Drive	**PAGE:** 2 of 2
GROUND SFC. ELEV.: 43.88 m. **DATUM:** NBGIC	**DATE:** October 31, 1990

DEPTH	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8								35.9	
	6	NQ	100%	RQD= 50"/60"			Mudstone, as above		▼
9									
10	7	NQ	30"/60"	RQD= 0%					
11								32.8	
	8	NQ	100%	RQD= 30"/60"			Sandstone fine grained, brown, faintly weathered		
12									
13	9	NQ	100%	RQD= 38"/48"					
14							End of borehole	30.0	
15									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1.
PROJECT:	New Solid Waste Landfill Site	**BORING:**	B.H. # 110
LOCATION:	Delong Drive	**PAGE:**	1 of 2
GROUND SFC. ELEV.:	44.45 m **DATUM:** NBGIC	**DATE:**	November 1, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	44.45	
	1	S	15"	1, 1 3, 4	4		Clayey silty SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC	4423	
1									
2	2	S	12"	8, 12 20, 14	32				
							Mudstone, brown, soft, poorly cemented, highly weathered at some sections	42.1	
3	3	S	13"	20, 21 38, 45					
4	4	NQ	100%	RQD= 21"/36"					
5	5	NQ	100%	RQD= 30"/60"					
6									
7	6	NQ	100%	RQD= 0					
8								36.5	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee

JOB No.: 2771-4.1

PROJECT: New Solid Waste Landfill Site

BORING: B.H. #110

LOCATION: Delong Drive

PAGE: 2 of 2

GROUND SFC. ELEV.: 44.45 m

DATUM: NBGIC

DATE: November 1, 1990

DEPTH	SAMPLE			Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8							Mudstone, as above	36.5	
	7	NQ	56"/ 60"	ROD= 20"/6"					
9									
							Bottom of borehole Groundwater not encountered for depth of hole	35.1	
10									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 111
LOCATION:	Delong Drive	PAGE:	1 of 2
GROUND SFC. ELEV.: 45.77 m	DATUM: NBGIC	DATE:	November 2, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								45.77	
	1	S	17"	1 for 12"			Organics		
				2, 3			Grey silty clayey sand	45.6	
							Clayey silty,SAND, some gravel, dark brown, loose to compact (TILL) SM-SC	45.5	
1									
2	2	S	14"	3, 4 7, 9	11				
							Mudstone, brown, highly weathered to residual soil	43.1	
3	3	S	13"	6, 16 19,20	35				
4									
5	4	S	9"	19,36 30 for 3"					
6	5	HQ							
							Siltstone to sandstone, fine grained, dark brown, slightly to moderately weathered	39.5	
7	6	NQ	100%	ROD= 36"/60"					
8								37.8	

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SOILS LOG

IENT: Westmorland/Albert Solid Waste Provisional Committee

JOB No.: 2771-4.

OJECT: New Solid Waste Landfill Site

BORING: B.H. #111

CATION: Delong Drive

PAGE: 2 of 2

ROUND SFC. ELEV.: 45.77 m

DATUM: NBGIC

DATE: November 2, 1990

PTH	SAMPLE				N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8								37.8	
	7	NQ	100%	RQD= 28"/60"			Siltstone to sandstone, as above		
9									
0	8	NQ	100%	RQD= 35"/60"					
1	9	NQ	100%	RQD= 0%					
							End of borehole No groundwater encountered for depth of borehole.	34.2	
2									
3									
4									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING: T.P. #1
LOCATION: Delong Drive		PAGE: 1 of 1
GROUND SFC. ELEV.: 42.96 m	DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE				N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
0							Organics	42.96	
							Grey silty clayey sand	42.8	
1							Clayey silty SAND, some gravel, dark brown, loose to compact (Till)	42.0	
2									
							Sandstone boulder		
3							Mudstone, brown, highly weathered to residual soil	40.0	▽
4									
							Bottom of test pit 4.6 m Water flowing along bedrock surface.	38.4	
5									
6									
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #2
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 43.87 m DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								43.87	
							Organics	43.7	
							Grey silty clayey sand	43.3	
1							Clayey silty SAND, some gravel, dark brown, loose to compact (Till)	41.5	
2									
3							Mudstone, brown, highly weathered to residual soil	40.7	▽
							Sandstone	40.5	
4							Bottom of test pit 3.4 m		
5							Water flowing along surface of sandstone.		
6									
7									
8									

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SOILS LOG

X

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #3
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 44.39 m DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	44.39	
							Grey silty clayey sand	44.2	
							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	43.8	
1									
2									
							Mudstone, brown, highly weathered to residual soil, becoming more competent with depth	42.0	∇
3									
4									
5									
							Sandstone seam at bottom		
6							Bottom of test pit 6.1 m Water flowing along the bedrock surface.	38.3	
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #4
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 46.61 m	DATUM: NBGIC	DATE:	October 17, 1990

DEPTH m	SAMPLE No.	TYPE	RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								46.61	
							Organics	46.4	
							Grey silty clayey sand	46.0	
1 2							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	43.9	▽
3							Mudstone, brown, highly weathered to residual soil.	43.2	
4 5 6 7 8							Bottom of test pit 3.4 m Water flowing along the bedrock surface.		

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #5
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 48.01 m	DATUM: NBGIC	DATE:	October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								48.01	
							Organics	47.8	
							Grey silty clayey sand	47.4	
1							Clayey silty SAND, some gravel, dark brown, compact (Till)		
2									
3								45.0	
							Mudstone, brown, highly weathered to residual soil becoming more competent with depth		
4									
5								42.5	
							Bottom of test pit 5.5 m Ground water not encountered		
6									
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #6
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 48.47 m DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								48.47	
							Organics	48.3	
							Grey silty clayey sand	47.9	
1							Clayey silty SAND, with gravel, dark reddish brown, compact (Till)	44.2	
2									
3									
4									
							Bottom of test pit 4.3 m due to extent of reach of backhoe Groundwater not encountered		
5									
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #7
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.:	47.38 m DATUM: NBGIC	DATE:	October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	47.38	
							Grey silty clayey sand	47.2	
1							Clayey silty SAND, with gravel, dark reddish brown, compact (Till) Sandstone boulder 1.9 m	46.8	
2 3							Mudstone, brown, highly weathered to residual soil	45.5	▽
4 5 6 7 8							Bottom of test pit 3.4 m Water flowing along the bedrock surface.	44.0	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #8
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 50.04 m — DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	50.04	
							Grey silty clayey sand	49.8	
1 2							Clayey silty SAND, with gravel, dark brown, compact (Till)	49.5	
3							Mudstone, brown, highly weathered to residual soil	47.3	
4 5 6 7 8							Bottom of test pit 3.7 m Groundwater not encountered	46.3	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #9
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 51.00 m DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								51.00	
							Organics		
								50.8	
							Grey silty clayey sand		
								50.4	
1							Clayey silty SAND, with gravel, dark reddish brown, compact (Till)		
2								48.9	
							Mudstone, brown, soft		
								48.3	
3							Bottom of test pit 2.7 m Groundwater not encountered		
4									
5									
6									
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #10
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 55.31 m DATUM: NBGIC	DATE: October 17, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	55.31	
								55.1	
							Grey silty clayey sand		
								54.8	
							Clayey silty SAND, some gravel, dark reddish brown, compact,(Till)		
1									
2									
							Sandstone boulder	52.6	▽
3									
4									
								51.0	
							Bottom of test pit 4.3 m		
5							Water seepage at elevation 52.6 meters.		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	T.P. #11
LOCATION:	Delong Drive	**PAGE:**	1 of 1
GROUND SFC. ELEV.: 56.21 m	**DATUM:** NBGIC	**DATE:**	Ocotber 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	56.21	
							Grey silty clayey sand	56.0	
1							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	55.7	
2							Mudstone, brown, soft	54.1	▽
3							Bottom of test pit 3.2 m Water flowing along the bedrock surface.	53.0	
4									
5									
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. # 12
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 55.77 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics - Surface water runoff	55.77	
							Grey silty clayey sand	55.6	▽
							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	55.3	
1									
2									
							Mudstone, brown, soft	53.7	
3									
							Bottom of test pit 3.2 m Water flowing along the surface of the till.	52.6	
4									
5									
6									
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:** 2771-4.1
PROJECT: New Solid Waste Landfill Site	**BORING:** T.P. #13
LOCATION: Delong Drive	**PAGE:** 1 of 1
GROUND SFC. ELEV.: 55.66 m **DATUM:** NBGIC	**DATE:** October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								55.66	
							Organics	55.5	
							Grey silty clayey sand	55.4	
1							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)		
2								53.4	
3							Mudstone, brown, soft		
								52.0	
4							Bottom of test pit 3.7 m Groundwater not encountered		
5									
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	**JOB No.:**	2771-4.1
PROJECT:	New Solid Waste Landfill Site	**BORING:**	T.P. # 14
LOCATION:	Delong Drive	**PAGE:**	1 of 1
GROUND SFC. ELEV.: 49.23 m	**DATUM:** NBGIC	**DATE:**	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	49.23	
							Grey silty clayey sand	49.0	
							Clayey silty SAND, some gravel, brown, compact (Till)	48.9	
1									
2									
							Siltstone, brown, slightly weathered	46.9	
3									
							Bottom of test pit 3.5 m Ground water not encountered	45.7	
4									
5									
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. # 15
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 52.63 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
								52.63	
0							Organics	52.4	
							Grey silty clayey sand	52.1	
1							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)		
2									
3									
4								48.0	
5							Bottom of test pit 4.6 m Groundwater not encountered		
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #16
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 55.97 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	55.97	
							Grey silty clayey sand	55.8	
1 2 3							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)	55.7	
4							Mudstone, brown, with sandstone seam	52.4	
5 6 7 8							Bottom of test pit 4.3 m Groundwater not encountered	51.7	

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SOILS LOG

Y

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #17
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 56.05 m DATUM: NBGIC	DATE: October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
								56.05	
0							Organics	55.9	
							Grey silty clayey sand	55.6	
1 2							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)	53.7	
							Sand	53.5	
3							Till as above	52.3	
4							Mudstone with sandstone seam	51.7	
5 6 7 8							Bottom of test pit 4.4 m Groundwater not encountered		

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #18
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 58.16 m DATUM: NBGIC	DATE: October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	58.16	
							Grey silty clayey sand	58.0	
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)	57.7	
1									
2									
3									
							Mudstone with sandstone seams	54.8	
4							Bottom of test pit 4.0 m Groundwater not encountered	54.2	
5									
6									
7									
8									

Acadia Consultants and Inspectors Limited

SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. # 19
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 57.69 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	57.69	
							Grey silty clayey sand	57.5	
							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	57.4	
4							Mudstone with sandstone seam	53.7	
							Bottom of test pit 4.3 m	53.4	
							Groundwater not encountered		

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #20
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 56.66 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
								56.66	
0							Organics	56.5	
							Grey silty clayey sand	56.1	
1							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)		
2								53.7	
3							Mudstone, brown, soft	52.7	
4							Bottom of test pit 4.0 m Groundwater not encountered		
5									
6									
7									
8									

Acadia Consultants and Inspectors Limited	SOILS LOG	
CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING: T.P. #21
LOCATION: Delong Drive		PAGE: 1 of 1
GROUND SFC. ELEV.: 53.29 m	DATUM: NBGIC	DATE: October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	53.29	
							Grey silty clayey sand	53.1	
							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (Till)	52.8	
1									
2									
3									
4							Mudstone at bottom		
							Bottom of test pit 4.6 m	48.7	
5							Ground water not encountered		
6									
7									
8									

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: T.P. #22
LOCATION: Delong Drive	PAGE: 1 of 1
GROUND SFC. ELEV.: 55.82 m DATUM: NBGIC	DATE: October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								55.82	
							Organics	55.6	
							Grey silty clayey sand	55.2	
							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)	52.1	
							Sandstone boulder	52.0	
							Bottom of test pit 3.8 m		
							Ground water not encountered		

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #23
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 56.58 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								56.58	
							Organics	56.4	
							Grey silty clayey sand	56.1	
							Clayey silty SAND, some gravel, dark reddish brown, compact (Till)		
1									
2									
3									
								52.9	
4							Bottom of test pit 3.7 m Ground water not encountered		
5									
6									
7									
8									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. # 24
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 42.80 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	42.80	
							Grey silty clayey sand	42.6	
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)	42.3	
1									
2									
3									
							Bottom of test pit 3.7 m Groundwater not encountered	39.1	
4									
5									
6									
7									
8									

Acadia Consultants and Inspectors Limited	**SOILS LOG**

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		**JOB No.:** 2771-4.1
PROJECT: New Solid Waste Landfill Site		**BORING:** T.P. # 25
LOCATION: Delong Drive		**PAGE:** 1 of 1
GROUND SFC. ELEV.: 43.51 m	**DATUM:** NBGIC	**DATE:** October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0							Organics	43.51	
							Grey silty clayey sand	43.3	
							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (Till)	43.2	
1									
2									
3							Bottom of test pit 3.0 m Groundwater not encountered	40.5	
4									
5									
6									
7									
8									

5

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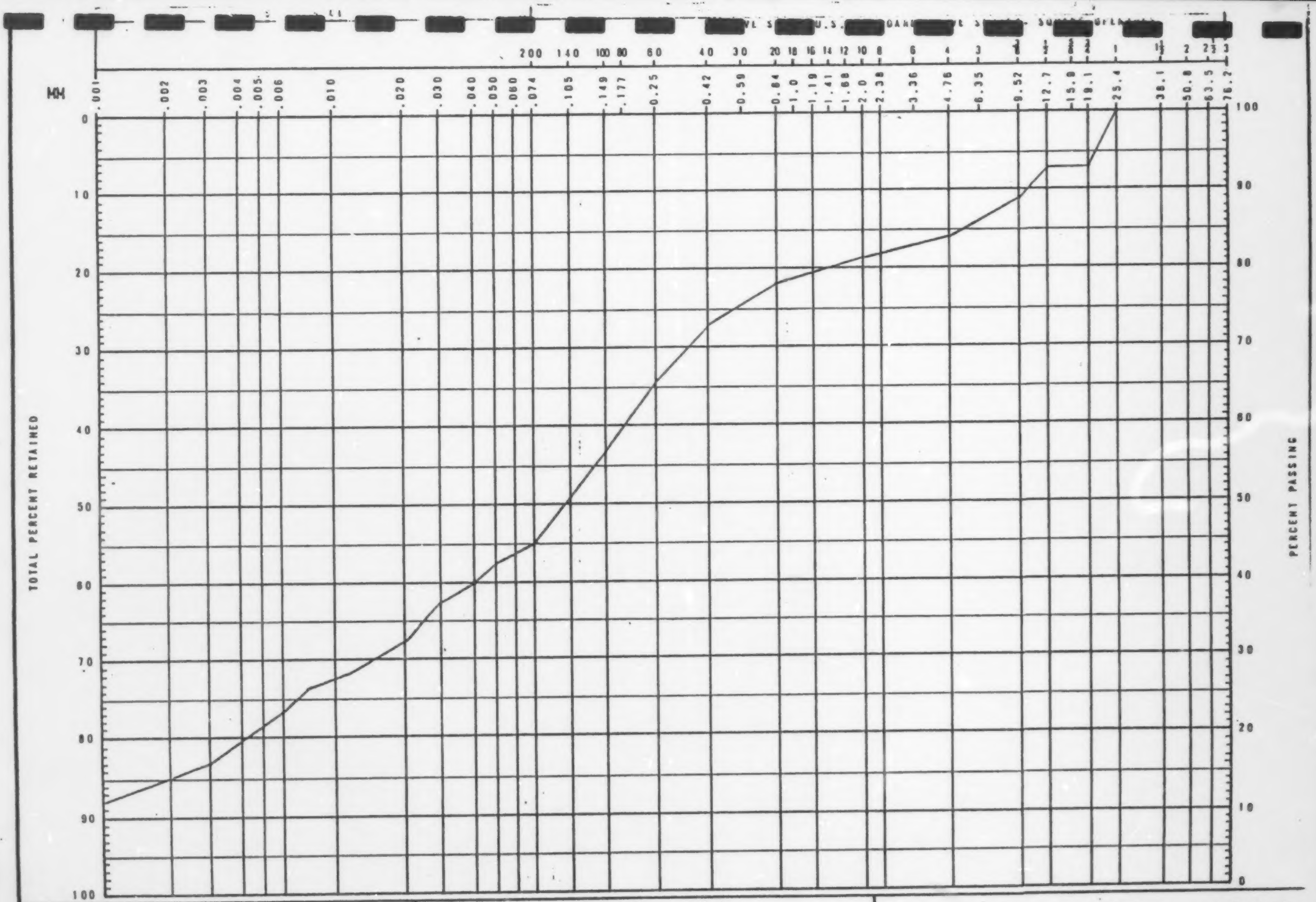
SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	T.P. #26
LOCATION:	Delong Drive	PAGE:	1 of 1
GROUND SFC. ELEV.: 42.53 m	DATUM: NBGIC	DATE:	October 18, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY		N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								42.53	
							Organics	42.3	
							Grey silty clayey sand	42.2	
							Clayey silty SAND, with gravel, dark reddish brown, compact to dense (Till)		
1									
2									
3							Sandstone boulder		
							Mudstone at bottom	38.8	
4							Bottom of test pit 3.7 m Groundwater not encountered		
5									
6									
7									
8									



DESCRIPTION AND LOCATION:
BH 101 Sample 2
Clayey silty SAND, some gravel

CLIENT: WESTMORLAND/ALBERT SOLID WASTE
PROJECT: DELONG DRIVE SITE
JOB NO: 2771 - 4.1

GRADING CHART - SOILS

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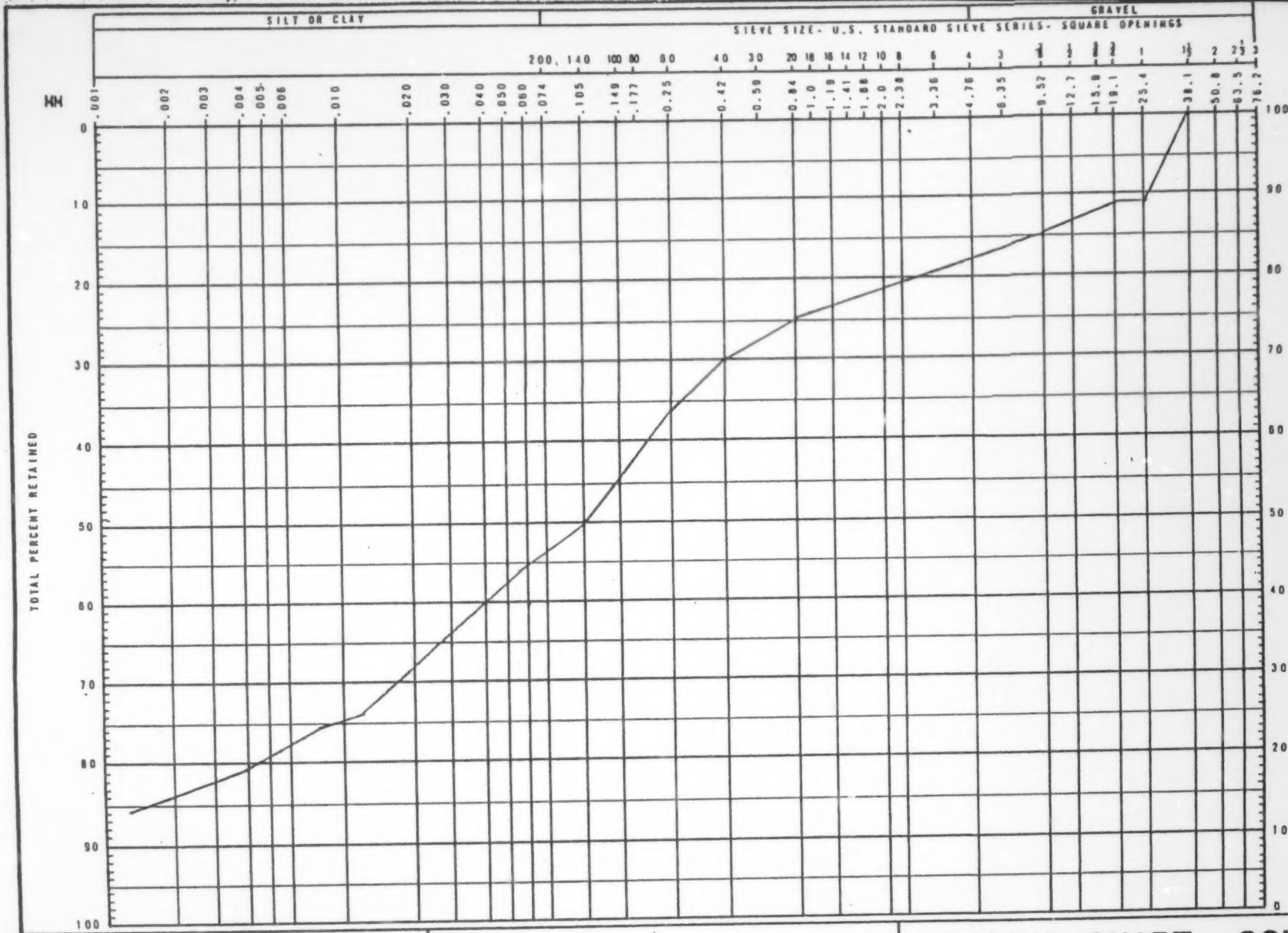

DESCRIPTION AND LOCATION:
BH 101 Sample 5
Clayey Silty SAND some gravel
SM-SC

CLIENT: WESTMORLAND/ALBERT SOLID WASTE

PROJECT: DELONG DRIVE SITE

JOB NO: 2771-4.1

GRADING CHART - SOILS

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BERRY MILLS ROAD SITE

WESTMORLAND/ALBERT SOLID WASTE

PROVISIONAL COMMITTEE

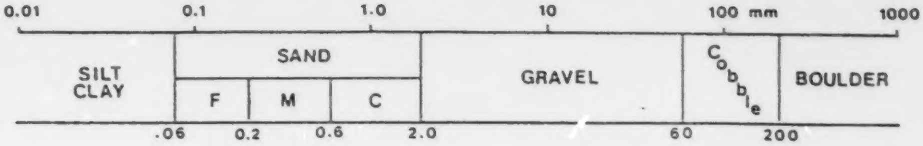
1990 BOREHOLE LOGS

GRAIN SIZE ANALYSES

DESCRIPTIVE TERMS - BORING LOGS

SOILS

GRAIN SIZE



COMPACTNESS gravel, sand, tills

N, RANGE	0 – 4	4 – 10	10 – 30	30 – 50	>50
DENSITY	V. LOOSE	LOOSE	MEDIUM	DENSE	V. DENSE

CONSISTENCY silt, clay

S, KPa	<12.5	12.5 – 25	25 – 50	50 – 100	100 – 200
CONSISTENCY	V. SOFT	SOFT	MEDIUM	STIFF	V. STIFF

ROCK

RQD	OVERALL QUALITY	FRACTURE SPACING
0 – 25	VERY POOR	<50 mm VERY CLOSE
25 – 50	POOR	50 – 300 mm CLOSE
50 – 75	FAIR	0.3 – 1 m MODERATE
75 – 90	GOOD	1 – 3m WIDE
90 – 100	EXCELLENT	>3m VERY WIDE

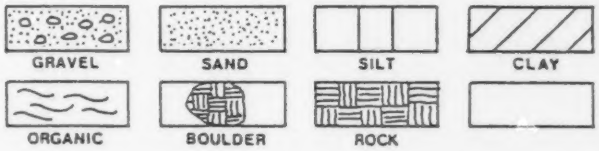
COMP. STR. MPa	0.85 – 3.5	3.5 – 14	14 – 55	55 – 220	>220
DESCRIPTION	V. WEAK	WEAK	MODERATE	STRONG	V. STRONG

SAMPLE TYPES (location to scale on log)

S	SPLIT TUBE	G	SHOVEL
T	SHELBY TUBE	H	CARVED BLOCK
P	PISTON	K	SLOTTED
F	AUGER	V	IN SITU VANE
W	WASH	NR	NO RECOVERY

ROCK CORES A(30mm); B(41mm); N(54mm)

LOG SYMBOLS



NOTATION AND SYMBOLS

N — standard penetration test; blows by 475 J drop hammer to advance Std. 50 mm O.D. split tube sampler 0.3 m

RQD — per cent of core consisting of hard, sound pieces in excess of 100 mm long (excluding machine breaks)

RECOVERY — sample recovery expressed as per cent or length

S — shear strength, kPa; vane ▼ ; penetrometer ■ ; unconfined ●
Sr — shear strength, remoulded; vane ▽ ; penetrometer □ ; unconfined O
Dd — dry density; t/m^3
W — natural moisture content, per cent X
PL — plastic limit, per cent ├──
LL — liquid limit, per cent ──┤
Groundwater Level ▼ ; seepage ▽

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4.1	
PROJECT: New Solid Waste Landfill Site		BORING: B.H. #201	
LOCATION: Berry Mills		PAGE: 1 of 2	
GROUND SFC. ELEV.: 44.93 m	DATUM: NBGIC	DATE: November 8, 1990	

DEPTH m	SAMPLE No.	TYPE	RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	16"	1 for 12" 1, 2			Organics	44.93	
							Grey and brown silty clayey sand	44.7	
							Sand	44.3	
1							Dark reddish brown, clayey-silty SAND, some gravel, loose to dense (TILL) SM-SC	43.8	
	2	S	10"	2, 3 5, 8	8				
2							Sandy silt seam at 39.9 m		
3	3	S	8"	5, 13 21	44				
							Mudstone, residual soil, brown, dense to very dense	41.5	
4									
	4	S		14, 24 25 for 2"					
5									
							Mudstone, brown, slightly weathered, soft	39.7	
	5	NQ	32"/48"	RQD= 27/48					
6	6	NQ	42"/ 48"	36/ 48					
7	7	NQ	100%	RQD 34/ 38					
8								36.9	

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LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: B.H. #201
LOCATION: Berry Mills	PAGE: 2 of 2
GROUND SFC. ELEV.: 44.93 m DATUM: NBGIC	DATE: November 8, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8							Mudstone, as above	36.9	
	8	NQ	100%	RQD 33/ 48					
9									
	9	NQ							
10									
							Bottom of borehole 10.7 m No groundwater encountered for depth of borehole.	34.2	
11									

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 202
LOCATION:	Berry Mills	PAGE:	1 of 2
GROUND SFC. ELEV.:	49.99 m DATUM: NBGIC	DATE:	November 8, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0								49.99	
	1	S	15"	3, 3 5, 5			Greyish brown silty sand, trace of clay	49.8	
							Clayey silty SAND, some gravel, dark reddish brown, dense (TILL) SM-SC		
1									
	2	S	6"	7, 37 50 for 1"					
2							Boulder		
								*	▼
3	3	S	10"	12, 18 27	45				
4									
								45.4	
5	4	NQ	12"/30"	RQD= 8"/30			Mudstone/siltstone, dark brown, soft, highly weathered, to 5.3 m becoming moderately to slightly weathered below this point		
	5	NQ	24"/30"	RQD= 16/30					
6	6	NQ	100%	RQD= 31"/48"					
7									
	7	NQ	100%	RQD= 39"/48"					
8								42.0	

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LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.:	2771-4.1
PROJECT: New Solid Waste Landfill Site		BORING:	B.H. #202
LOCATION: Berry Mills		PAGE:	2 of 2
GROUND SFC. ELEV.: 49.99 m	DATUM: NBGIC	DATE:	November 8, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8	7	NQ						42.0	
9	8	NQ	100%	RQD= 28/ 48			Calcareous deposits at 10.5 and 10.6 m		
10	9	NQ	100%	RQD= 30/ 48			Grades to siltstone at 10.6 m		
11							Bottom of borehole 11 m * Piezometric water level noted in piezometer sealed in the bedrock.	39.0	

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 203
LOCATION:	Berry Mills	PAGE:	1 of 2
GROUND SFC. ELEV.: 57.79 m	DATUM: NBGIC	DATE:	November 9, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
								57.79	
0	1	S	13"	1, 2 2, 4	4		Organics	57.6	
							Brown silty clayey sand	57.3	▽
1							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC		
2	2	S	11"	6, 8 15	23				
3	3	S	9"	10, 16 21	37				
4								53.5	
5	4	S	14"	10, 20 30, 50	50 for 1"		Mudstone, dark brown, soft, weakly cemented, highly weathered becoming moderately to slightly weathered with depth		
6	5	NQ	4'/ 5'	RQD= 33/ 60					
7	6	NQ	100%	RQD= 20"/ 48"					
8	7	NQ	100%	RQD= 31/ 48				49.8	

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LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: B.H. #203
LOCATION: Berry Mills	PAGE: 2 of 2
GROUND SFC. ELEV.: 57.79 m DATUM: NBGIC	DATE: November 9, 1990

DEPTH m	SAMPLE NO.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8	7	NQ					Mudstone, as above	49.8	
9	8	NQ	100%	RQD= 38/48					
10	9		100%	RQD= 35/48			Grades to a siltstone at 10.2 m		
11							Bottom of borehole 11 m Water flowing along the surface of the till.	46.8	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee
JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site
BORING: B.H. #204
LOCATION: Berry Mills
PAGE: 1 of 2
GROUND SFC. ELEV.: 57.26 m
DATUM: NBGIC
DATE: November 9, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	12"	1, 2 2, 3	4		Fill	57.26	
							Organics	57.1	
							Greyish brown silty sand	57.0	▼
								* 56.7	
1							Clayey silty SAND, some gravel, dark reddish brown, compact to dense (TILL) SM-SC		
2	2	S	11"	6, 8 8, 10	16		Boulder		
3	3	S	13"	10, 16 19	35				
4							Till, as above		
	4	S	3"	15, 20	35				
5	5	NQ					Boulder, 280 mm diameter		
6	6	NQ					Till, as above		
7	7	NQ	42/ 48"	RQD= 17/ 48				49.7	
8							Siltstone	49.3	

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LOG (SOILS)

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. #204
LOCATION:	Berry Mills	PAGE:	2 of 2
GROUND SFC. ELEV.:	57.26 m DATUM: NBGIC	DATE:	November 9, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8	7	NQ					Siltstone interbedded with mudstone and sandstone, brown, slightly weathered	49.3	
9									
	8	NQ	100%	RQD= 31/ 48					
10									
							Sandstone, brown grading to grey, fine-grained, slightly weathered	46.9	
11	9	NQ	100%	RQD= 46/ 48					
12	10	NQ	100%	RQD= 100%					
							Mudstone, dark brown, soft	44.5	
13	11	NQ	100%	RQD= 29/ 48					
14							Bottom of borehole 14 m * Piezometric water level noted in piezometer sealed in the bedrock.	43.3	

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SOILS LOG

CLIENT: Westmorland/Albert Solid Waste Provisional Committee		JOB No.: 2771-4 .1	
PROJECT: New Solid Waste Landfill Site		BORING: B.H. # 205	
LOCATION: Berry Mills		PAGE: 1 of 2	
GROUND SFC. ELEV.: 62.44 m	DATUM: NBGIC	DATE: November 7, 1990	

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0	1	S	14"	1 for 12" 4, 4			Organics	62.44	
							Grey silty clayey sand	62.2	
							Sandy clayey SILT, some gravel, dark reddish brown, very stiff to hard (TILL) CL-ML	62.1	
1									
	2	S	10"	26, 11 12, 17	23		Boulder		
2									
3									
	3	S	19"	7, 12 16, 17	28		Liquid Limit 19% Plastic Limit 15% Moisture Content 10%		
4									
5	4	S	0	12, 20 26	46				
							Mudstone, brown, soft, weakly cemented	56.6	
6									
	5	S		17, 25 27			Green calcareous deposits from 6.0 to 6.75 m depth		
7	6	NQ	24"/ 48"	RQD= 15"/48"					
	7	NQ	100%	RQD= 13/ 48"					
8								54.4	

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LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: B.H. #205
LOCATION: Berry Mills	PAGE: 2 of 2
GROUND SFC. ELEV.: 62.44 m DATUM: NBGIC	DATE: November 7, 1990

DEPTH m	SAMPLE			Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
	No.	TYPE	RECOVERY						
8								54.4	
	7	NQ					Mudstone, as above		
9	8	NQ	100%	RQD= 11/ 48					
10	9	NQ	100%	RQD= 40/ 48					
11	10	NQ	100%	RQD= 36/ 48					
12							Bottom of borehole 12.2 m	50.2	
13							No groundwater encountered for depth of borehole.		

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SOILS LOG

CLIENT:	Westmorland/Albert Solid Waste Provisional Committee	JOB No.:	2771-4.1
PROJECT:	New Solid Waste Landfill Site	BORING:	B.H. # 206
LOCATION:	Berry Mills	PAGE:	1 of 2
GROUND SFC. ELEV.:	61.44 m DATUM: NBGIC	DATE:	November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
0			17	1 for 12"			Organics	61.44	
	1	S		3, 7			Grey to brown silty clayey sand	61.2	
							Clayey silty SAND, some gravel, dark reddish brown, compact-to dense (TILL) SC-SM Liquid Limit 21% Plastic Limit 14% Moisture Content 17% Cobble	60.9	▽
1									
	2	S	8"	4, 20 13, 16	33				
2									
3	3	S	9"	10, 22 26	48		Till, as above		
4									
	4	S	13"	17, 18 28	46				
5									
							Mudstone, brown, soft, weakly cemented	55.9	
6									
	5	S	8"	16, 20 31	51				
7	6	NQ	30/48"	RQD= 20/48					
	7	NQ	100%	RQD= 28/48					
8								53.4	

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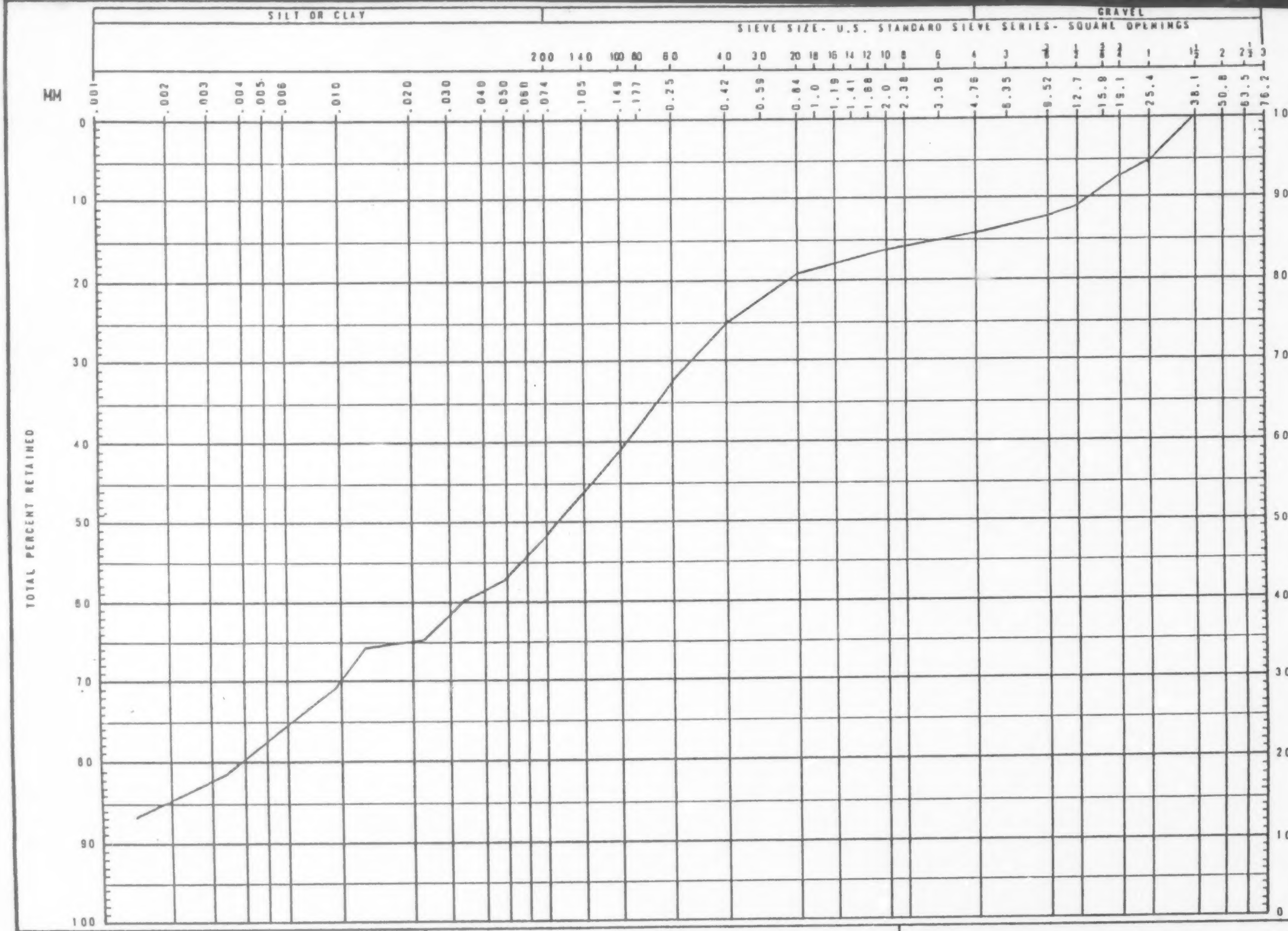
LOG (SOILS)

CLIENT: Westmorland/Albert Solid Waste Provisional Committee	JOB No.: 2771-4.1
PROJECT: New Solid Waste Landfill Site	BORING: B.H. #206
LOCATION: Berry Mills	PAGE: 2 of 2
GROUND SFC. ELEV.: 61.44 m DATUM: NBGIC	DATE: November 7, 1990

DEPTH m	SAMPLE No.	SAMPLE TYPE	SAMPLE RECOVERY	Blows per 150 mm	N	LOG	DESCRIPTION & NOTES	ELEV. m	WATER
8								53.4	
	7	NQ					Mudstone, as above		
9	8	NQ	44/48	RQD= 23/ 48					
10	9	NQ	100%	RQD= 29/ 48					
11	10	NQ	100%	RQD= 31/ 48					
12								49.2	
							Bottom of borehole 12.2 m		
13							Water flowing along the surface of the till.		



DESCRIPTION AND LOCATION:
BH 204 Sample 2
Clayey Silty SAND, some gravel
SC-SM

CLIENT: WESTMORLAND/ALBERT SOLID WASTE

PROJECT: BERRY MILLS SITE

JOB NO: 2771 - 4.1

GRADING CHART - SOILS

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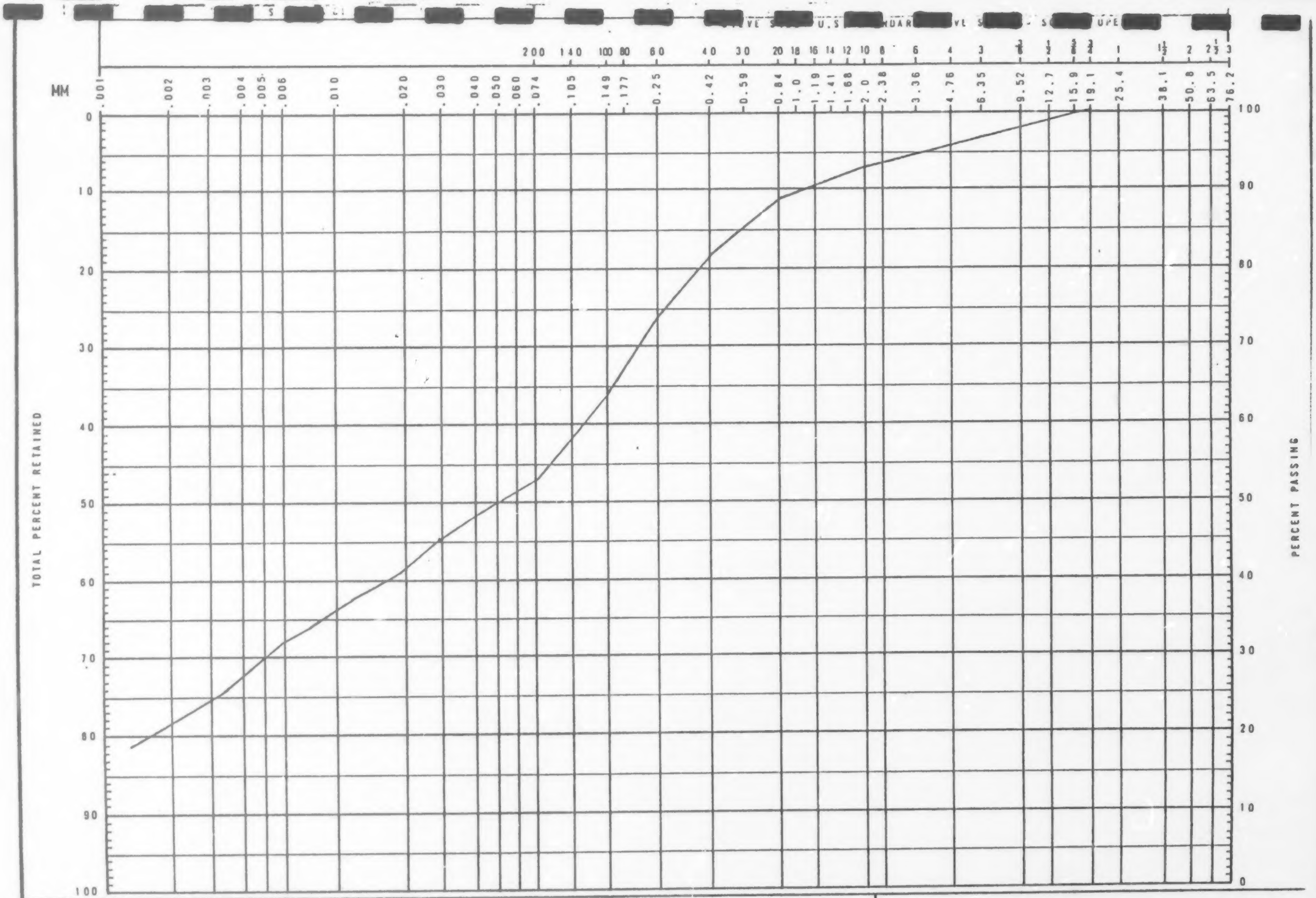


DESCRIPTION AND LOCATION:
BH 205 Sample 3
Sandy Clayey SILT, trace of gravel CL-ML

CLIENT: WESTMORLAND/ALBERT SOLID WASTE
PROJECT: BERRY MILLS SITE
JOB NO: 2771 - 4.1

GRADING CHART - SOILS

Acadia Consultants and Inspectors Limited

- 205

BERRY MILLS ROAD SITE

WESTMORLAND/ALBERT SOLID WASTE

PROVISIONAL COMMITTEE

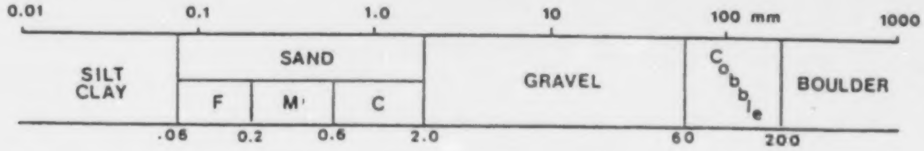
1986 BOREHOLE LOGS

GRAIN SIZE ANALYSES

DESCRIPTIVE TERMS - BORING LOGS

SOILS

GRAIN SIZE



COMPACTNESS gravel, sand, tills

N,RANGE	0 - 4	4 - 10	10 - 30	30 - 50	>50
DENSITY	V. LOOSE	LOOSE	MEDIUM	DENSE	V. DENSE

CONSISTENCY silt, clay

S,KPa	<12.5	12.5 - 25	25 - 50	50 - 100	100 - 200
CONSISTENCY	V. SOFT	SOFT	MEDIUM	STIFF	V. STIFF

ROCK

RQD	OVERALL QUALITY
0 - 25	VERY POOR
25 - 50	POOR
50 - 75	FAIR
75 - 90	GOOD
90 - 100	EXCELLENT

FRACTURE SPACING

<50 mm VERY CLOSE
50 - 300 mm CLOSE
0.3 - 1 m MODERATE
1 - 3 m WIDE
>3 m VERY WIDE

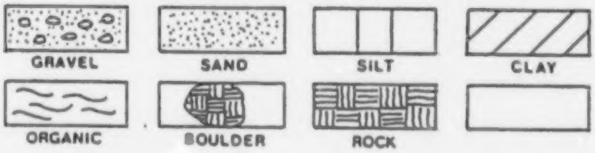
COMP. STR. MPa	0.85 - 3.5	3.5 - 14	14 - 55	55 - 220	>220
DESCRIPTION	V. WEAK	WEAK	MODERATE	STRONG	V. STRONG

SAMPLE TYPES (location to scale on log)

S	SPLIT TUBE	G	SHOVEL
T	SHELBY TUBE	H	CARVED BLOCK
P	PISTON	K	SLOTTED
F	AUGER	V	IN SITU VANE
W	WASH	NR	NO RECOVERY

ROCK CORES A(30mm); B(41mm); N(54mm)

LOG SYMBOLS



NOTATION AND SYMBOLS

N — standard penetration test; blows by 475 J drop hammer to advance Std. 50 mm O.D. split tube sampler 0.3 m

RQD — per cent of core consisting of hard, sound pieces in excess of 100 mm long (excluding machine breaks)

RECOVERY — sample recovery expressed as per cent or length

S — shear strength, kPa; vane ▼ ; penetrometer ■ ; unconfined ●
Sr — shear strength, remoulded; vane ▽ ; penetrometer □ ; unconfined O
Dd — dry density; t/m^3
W — natural moisture content, per cent X
PL — plastic limit, per cent ⊢——
LL — liquid limit, per cent ——⊣
Groundwater Level ▼ ; seepage ▽

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BORING LOG (SOILS)

CLIENT: City of Moncton
JOB No.: 272-262
BORING: 1
PROJECT: Proposed Solid Waste Landfill
DATE: Jan.27,1986
PAGE: 1 of 1
LOCATION: N 756 073.289 E 423 846.655
GROUND SFC. ELEV. 195.0 ft.
DATUM: Geodetic

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0	1	S	4		TOPSOIL and grey to brown sandy silt	195.0	
						193.0	
5	2	S	53		Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
10	3	S	44				
15	4	S	62				
20							
25	5	S	106			169.0	
					Decomposed shale - very weak rock (very stiff soil)		
30							
35	6	S	65 for 4"			159.7	
					End of boring 35'4"		
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton	JOB No.: 272-262
	BORING: 2
PROJECT: Proposed Solid Waste Landfill	DATE: Jan 27/86
	PAGE: 1 of 1
LOCATION: N 755 746.680 E 423 708.575	
GROUND SFC. ELEV. 188.4 ft.	DATUM: Geodetic

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						188.4	
	1	S	4		TOPSOIL and grey to brown sandy silt	186.4	
5	2	S	31		Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
10	3	S	30		- 48.4% passing #200		▼
15							
20	4	S	7				
25	5	S	103			161.9	
30					Decomposed shale - very weak rock (very stiff soil)		
35	6	S	65 for 4"			152.9	
					End of boring 35'6"		
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 3
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 27/86	PAGE: 1 of 1
LOCATION: N 755 954.562 E 423 441.942			
GROUND SFC. ELEV. 194.9 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						194.9	▼
	1	S	6		TOPSOIL	193.4	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
5	2	S	37				
10	3	S	55				
15	4	S	62				
20						171.9	
					Very weak shale and siltstone - severely weathered		
25	5	S	51 for 5"				
30							
35						159.6	
	6	S	50 for 4"		End of boring 35'4"		
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton
JOB No.: 272-262
BORING: 4
PROJECT: Proposed Solid Waste Landfill
DATE: Jan 28/86
PAGE: 1 of 1
LOCATION: N 755 669.027 E 423 075.759
GROUND SFC. ELEV. 184.0 ft.
DATUM: Geodetic

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						184.0	▼
	1	S	2		TOPSOIL	183.0	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders - 55.8% passing #200		
5	2	S	21				
10	3	S	37				
15							
20	4	S	50 for 3"				
25					Very weak shale and siltstone - severely weathered	159.0	
30	5	F	42 for 0"				
					End of boring 33'0"	151.0	
35							
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton

JOB No.: 272-262

BORING: 5

PROJECT: Proposed Solid Waste Landfill

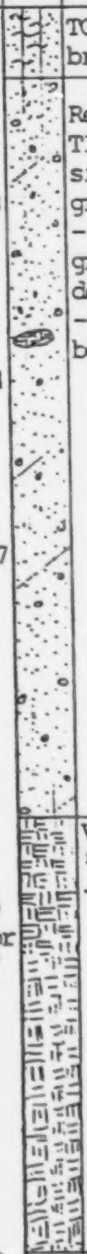
DATE: Jan 28/86

PAGE: 1 of 1

LOCATION: N 755 856.663 E 423 134.843

GROUND SFC. ELEV. 194.5 ft.

DATUM: Geodetic

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						194.5	▼
	1	S	7		TOPSOIL and grey to brown sandy silt		
						193.0	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
5	2	S	28				
10	3	S	44				
15	4	S	47				
20							
						171.5	
					Very weak shale and siltstone - severely weathered		
25	5	S	50 for 2"				
30							
35						159.2	
	6	S	50 for 3"		End of boring 35' 3"		

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BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 6
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 28/86	PAGE: 1 of 1
LOCATION: N 756 139.798 E 423 507.868			
GROUND SFC. ELEV. 199.1 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0	1	S	4		TOPSOIL and grey to brown sandy silt	199.1	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders	197.1	
5	2	S	17				
10	3	S	67		-42.4% passing #200		
					Very weak shale and siltstone - severely weathered	186.1	
15	4	S	45 for 1"		End of boring 15'1" No groundwater encountered	184.0	
20							
25							
30							
35							

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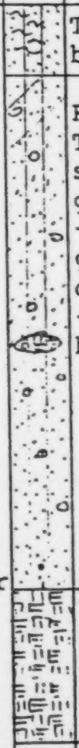
BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 7
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 28&29/86	PAGE: 1 of 1
LOCATION: N 756 330.336 E 423 780.438			
GROUND SFC. ELEV. 199.4 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						199.4	
	1	S	14		TOPSOIL and grey to brown sandy silt	197.4	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
5	2	S	16				
							▼
10	3	S	22				
15	4	S	61 for 8"			183.9	
					Very weak shale and siltstone - severely weathered		
20	5	S	50 for 5"			178.5	
					End of boring 20'11"		
25							
30							
35							
40							



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BORING LOG (SOILS)

CLIENT: City of Moncton		**JOB No.:** 272-262	**BORING:** 8
PROJECT: Proposed Solid Waste Landfill		**DATE:** Jan 28/86	**PAGE:** 1 of 1
LOCATION: N 756 308.450 E 423 355.718			
GROUND SFC. ELEV. 203.7 ft.	**DATUM:** Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0	1	S	3		TOPSOIL and grey to brown sandy silt	203.7	
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders	201.7	
5	2	S	23				
10	3	S	59				▽
15	4	S	56 for 6"				
					Decomposed shale - very weak rock (very stiff soil)	185.7	
20	5	S	43 for 3"			183.0	
					End of boring 20' 3"		
25							
30							
35							
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 9
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 28/86	PAGE: 1 of 1
LOCATION: N 756 194.418 E 422 931.530			
GROUND SFC. ELEV. 204.1 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0	1	S	12		TOPSOIL and grey to brown sandy silt	204.1 202.6	▼
5	2	S	20		Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders		
10	3	S	57		- 52.7% passing #200		
15	4	S	33 for 6"			186.1	
20					Decomposed shale - very weak rock (very stiff soil)	178.6	
25	5	S	60 for 6"		End of boring 25' 6"		
30							
35							
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 10
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 29/86	PAGE: 1 of 1
LOCATION: N 756 158.382 E 424 105.218			
GROUND SFC. ELEV. 190.8 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0	1	S	3		TOPSOIL and grey to brown sandy silt	190.8	▼
					Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel)	188.8	
5	2	S	25		- medium dense to dense growing denser with depth - occasional cobbles and boulders		
10	3	S	51		- 43.2% passing #200		
					Decomposed shale - very weak rock (very stiff soil)	177.8	
15	4	S	42 for 4"		End of boring 15' 10"	175.0	
20							
25							
30							
35							
40							

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BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 11
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 29/86	PAGE: 1 of 1
LOCATION: N 775 915.612 E 424 146.190			
GROUND SFC. ELEV. 186.3 ft.	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0					TOPSOIL	186.3	▼
	1	S	5		Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders	185.3	
5	2	S	22				
10	3	S	45 for 6"		Decomposed shale - very weak rock (very stiff soil)	176.3	
15	4	S	50 for 5"		Very weak shale and siltstone - severely weathered	171.3	
20					End of boring 20'	166.3	
25							
30							
35							

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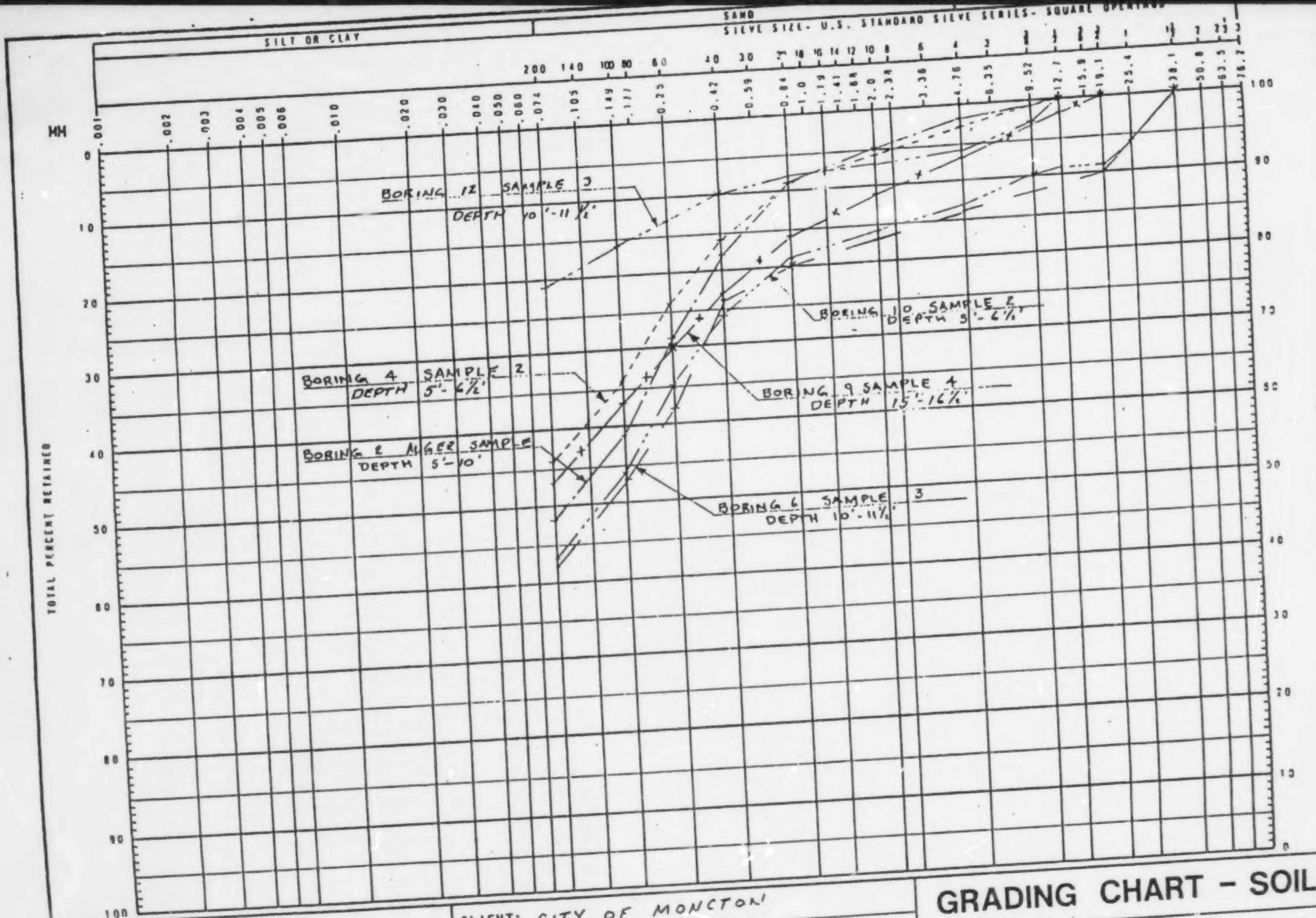
BORING LOG (SOILS)

CLIENT: City of Moncton		JOB No.: 272-262	BORING: 12
PROJECT: Proposed Solid Waste Landfill		DATE: Jan 29/86	PAGE: 1 of 1
LOCATION: N 755 792.883 E 424 105.565			
GROUND SFC. ELEV. 182.3 ft	DATUM: Geodetic		

DEPTH FT.	SAMPLE No.	SAMPLE TYPE	SAMPLE N	LOG	DESCRIPTION	ELEV. FT.	WATER
0						182.3	▼
	1	S	4		TOPSOIL and grey to brown sandy silt	180.3	
5	2	S	22		Reddish brown GLACIAL TILL (mixture of clay, silt and sand with some gravel) - medium dense to dense growing denser with depth - occasional cobbles and boulders	172.3	
10	3	S	45		Decomposed shale - very weak rock (very stiff soil) - 79.2% passing #200		
15	4	S	57			165.3	
					Very weak shale and siltstone - severely weathered	162.3	
20	5	S	40 for 1"		End of boring 20' 1"		
25							
30							
35							
40							



DESCRIPTION AND LOCATION:
INSITU SOIL SAMPLES

CLIENT: CITY OF MONCTON
PROJECT: PROPOSED DUMP SITE
JOB NO: 272-262

GRADING CHART - SOIL

Acadia Consultants and Inspectors Limited

APPENDIX C1

Borehole Well Logs

BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT № 747
LOCATION DeLong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE № TH-01a
DATES : BORING May 1991 WATER LEVEL 41.63 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR ROD	HYDROCARB. VAPORS	
0	42.58	Top of Casing								
		OVERBURDEN Red clay gradational to sandy clay		▽						41.63 masl Static water level
	39.58	Compact denser red clay								
5	37.58	Mudstone - reddish brown, soft 50% clay 50% silts								36.47 Bottom of 100 mm ID casing set in a bentonite seal
	35.88									
	34.98	Mudstone as above. Harder End of Hole								
10										
15										
20										

Prepared by : MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT № 747

LOCATION Delong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE № TH-D1b

DATES : BORING May 1991 WATER LEVEL 39.95 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	42.84	Top of Casing								
		OVERBURDEN Red clay graditional to sandy clay								
	39.84	Compact red clay to reddish brown mudstone		▼						39.95 masl Static water level
5										
	35.24	Brown very soft siltstone and sandstone								
10										31.94 masl Bottom of 100 mm ID casing set in a bentonite seal
	30.64	Very fine-grained sandstone and siltstone. Minor thin soft clay beds.								
	29.14	Soft brown clay. Minor siltstone beds. Head drops quickly at 15.8m								
15										
	27.04	Interbedded hard siltstone and soft clay								27.04 masl Drill head drops quickly
	26.04	Interbedded hard fine-grained sandstone and siltstone								24.78 masl Fracture zone
	24.54	Hard red-brown siltstone								
20										
23	19.94	End of Hole								

Prepared by : MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Delong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-02a

DATES : BORING May 1991 WATER LEVEL 47.29 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0	48.37	Top of Casing								
		OVERBURDEN Sandy soil, water saturated at 3.6m depth. Before casing was installed water quickly filled casing hole to 2.0m depth.		▼						47.29 masl Static water level
5	43.77									
	43.17	Hard sandstone								
	42.27	Dense clay, water saturated								41.97 Bottom of 100 mm ID casing set in a bentonite seal
	40.77	Red and light grey soft claystone								
		End of Hole								
10										
15										
20										

Prepared by : MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Delong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE NºTH-02b

DATES : BORING May 1991 WATER LEVEL 46.95 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	48.40	Top of Casing								
		OVERBURDEN Sandy soil, water saturated at 3.6m depth. Before casing was installed water quickly filled casing hole to 2.0m depth.		▼						46.95 masl Static water level
5	43.80	Sandstone grading through siltstone. Dense clay, water saturated.								
	40.80	Red to grey claystone Minor interbedded fine-grained sandstone								
	39.39	Red siltstone and fine-grained sandstone. Hard.								
10	37.80	Red mudstone. Approximately 50% silt and 50% clay.								37.40 masl Bottom of 100 mm ID casing set in a bentonite seal.
15	34.70	Red claystone with hard siltstone interbeds.								34.20 masl Return to surface lost and recovered 33.00 masl Return to surface lost and recovered
	30.10	Hard, medium-grained brownish grey sandstone.								
20	28.60	Hard siltstone and very fine-grained sandstone								28.40 masl Return to surface lost and recovered
23	25.40	End of Hole								Prepared by : MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG
PROJECT Nº 747
LOCATION DeLong Drive Proposed Landfill Site, Moncton, N.B.
BOREHOLE Nº TH-03a
DATES: BORING May 1991
WATER LEVEL 54.93 masl
DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY	N - VALUE OR ROD	HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0	56.44	Top of Casing								
		OVERBURDEN Silty sand		▼						54.93 masl Static water level
	53.44	Pebbles and cobbles in sandy matrix								
5	51.84	Soft sandy clay								
	48.84	Red claystone - soft, augers easily								
10	46.64	Red claystone, Hard with interbedded silt and sandstone beds								46.04 masl Bottom of 100 mm ID casing set in a bentonite seal
	44.24	Hard red siltstone. Minor softer claystone interbeds								
	42.74	Very fine-grained soft red sandstone								
15	41.24	Soft red mudstone								
	39.64									
	38.14	Hard red siltstone								
20	36.64	Siltstone grading downwards into fine-grained sandstone								
	35.84	Soft red claystone								36.44 masl Drill head drops with reduction in water to surface
	35.14	Harder red siltstone								
		Hard claystone and siltstone								35.34 Drill head drops quickly
	33.54	END OF HOLE								

Prepared by: MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Delong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-03b

DATES: BORING May 1991 WATER LEVEL 46.91 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	56.24	Top of Casing								
		OVERBURDEN Silty sand								
	53.24	Pebbles and cobbles in sandy matrix								
5	51.64	Soft sandy clay								
	48.64	Red claystone: - soft augers easily		▼						46.91 masl Static water level
10	46.44	Hard with interbedded silt and sandstone beds								
	44.04	Hard red siltstone Minor softer claystone interbeds								
	42.64	Very fine-grained soft red sandstone								
15	41.04	Soft red mudstone								
	39.44	Hard red siltstone								
	37.94	Siltstone grading downwards into fine-grained sandstone								35.64 masl Drill head drops quickly with reduction in water return
	36.44									
20	35.64	Soft red claystone								
	34.94	Harder red siltstone								
		Soft claystone and siltstone								

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BOREHOLE RECORD

2/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION DeLong Drive Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-03b

DATES: BORING May 1991 WATER LEVEL 46.91 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
25		Soft claystone and siltstone								
	30.34	Red-brown Hard claystone and siltstone								29.84 masl Bottom of 100 mm ID casing set in a bentonite seal
	28.84	Red-brown hard siltstone with minor soft claystone interbeds								
30	27.34	Moderately hard red-brown mudstone								
35	25.74	Very fine-grained red-brown sandstone and siltstones. Hard and massive.								
40	17.24	Red-brown massive siltstone. Lighter in colour than previous unit.								16.64 masl Water return disrupted 13.64 masl Water return disrupted

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BOREHOLE RECORD

3/3

CLIENT ACI Limited
FIELD LOG
PROJECT Nº 747
LOCATION Delong Drive Proposed Landfill Site, Moncton, N.B.
BOREHOLE NºTH-03b
DATES: BORING May 1991
WATER LEVEL 46.91 mesl
DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB VAPORS	INSTRUMENTATION DETAILS
45		Red-brown massive siltstone								
	10.54	End of Hole								

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-B1a

DATES: BORING May 1991 WATER LEVEL 42.60 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	44.03									
		OVERBURDEN Dry soil composed of 70% silt, 20% clay, 10% sand		▼						42.60 masl Static water level
	39.53									
5		Soft moderately hard siltstone								37.93 Bottom of 100 mm ID casing set in a bentonite seal
	37.03									
	36.43	Soft fine-grained sandstone End of Hole								
10										
15										
20										

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-B1b

DATES: BORING May 1991 WATER LEVEL 42.58 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB VAPORS	INSTRUMENTATION DETAILS
0	43.71	OVERBURDEN Dry soil composed of70% silt, 20% clay, 10% sand		▼						42.58 masl Static water level
5	39.11	Soft moderatly hard siltstone								
	36.71									
	36.11	Hard siltstone								
10		Very hard silty claystone dark brown. 20% silt, 80% clay								
	33.01									
	32.11	Fire to medium-grained Sandstone								32.71 masl Bottom of 100 mm ID casing set in a bentonite seal.
15		Interbedded siltstone and fine to medium-grained sandstone								
20	20.81	END OF HOLE								

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747
LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-82a
DATES: BORING May 1991 WATER LEVEL 59.54 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N - VALUE OR RQD	SAMPLES: HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
	60.41	Top of Casing								
0		OVERBURDEN Sandy clay with pebbles and cobbles. Minor large boulders near bedrock contact		▼						59.54 masl Static water level
	55.61									
5	54.01	Weathered sandstone bedrock. Moderately soft becoming harder at 54.01								54.91 masl Bottom of 100 mm ID casing set in a bentonite seal
		Hard medium-grained greenish brown sandstone								
	52.81	End of Hole								
10										
15										
20										

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-82b

DATES: BORING May 1991 WATER LEVEL 55.19 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB VAPORS	
0	60.40	Top of Casing								
		OVERBURDEN Sandy clay with pebbles and cobbles. Minor large boulders near bedrock contact								
5	55.60	Weathered sandstone bedrock. Moderately soft becoming harder at 53.99m		▼						55.19 masl Static water level
	54.00	Hard medium-grained greenish brown sandstone, coarser-grained with conglomerate beds near base.								
10	51.30	Medium-grained sandstone grading downwards into siltstone								
15	49.70	Soft to moderately hard red claystone								49.10 masl Bottom of 100 mm ID casing set in a bentonite seal
	43.70	Very fine-grained red sandstone								
	42.70	Fine-medium-grained sandstone and conglomerate Appears to be heavily fractured								41.20 masl 40.70 masl Numerous fractures
20	40.60	Medium-grained sandstone interbedded with claystone								
	39.10	Hard claystone grading to soft at bottom of hole								

37.60 End of Hole

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT № 747

LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE № TH-B3a

DATES: BORING May 1991 WATER LEVEL 55.44 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0	56.26	Top of Casing								
		OVERBURDEN Silty-clay. Dry soil.		▼						55.44 masl Static water level
5 10	52.66	Soft moderately hard red claystone with minor interbedded siltstones								49.56 masl Bottom of 100 mm ID casing set in a bentonite seal
15	41.06	Interbedded fine-grained sandstones and siltstones Water intersected in this unit.								
	37.96 36.76	Soft claystone								
20	36.16	Hard fine-grained sandstone								
	35.28	Soft claystone								
	34.36	Fine-grained sandstone								
	33.38	Hard siltstone End of Hole								

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BOREHOLE RECORD

1/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Barry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-83b

DATES: BORING May 1991 WATER LEVEL 46,33 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0	53.61	Top of Casing								
		OVERBURDEN Silty clay. Dry soil.								
5	56.70	Soft- moderately hard red claystone with minor interbedded siltstones								
10				▼						46.33 masl Static water level
15	41.10	Interbedded fine-grained sandstones and siltstones. Water intersected in this unit.								
	38.00	Soft claystone								
20	36.80 36.20	Hard fine-grained sandstone								
	35.30	Soft claystone								
	34.30	Fine-grained sandstone								

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BOREHOLE RECORD

2/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747
LOCATION Berry Mills : Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-83b
DATES : BORING May 1991 WATER LEVEL 46.33 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
25		Interbedded red sandstone and minor siltstone								
	30.40	Grey brown hard medium-grained sandstone								29.81 masl Bottom of 100 mm ID casing set in a bentonite seal
30	28.90	Hard red siltstone.								27.91 masl 27.71 masl Drill head drops due to fractures 26.71 masl in siltstone
	24.30	Red claystone moderately hard								
35	21.30	Hard red-brown siltstone interbedded with softer brown claystone. Water return disrupted frequently during drilling								
40	16.70	Grey-brown claystone with minor interbedded siltstone								
	13.60	Red-brown claystone distinct colour change from above.								

Prepared by : MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

3/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Berry Mills Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-83b

DATES: BORING May 1991 WATER LEVEL 46.33 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0										
		Red brown claystone								
45										
	10.61	End of Hole								

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R1a.

DATES: BORING May 1991 WATER LEVEL 123.41 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	129.09	Top of Casing								
		OVERBURDEN Green sandy till changigg to a red sandy till								
	126.66	Pebble and cobble till with sandy matrix								
5	124.48	Hard pan cemented till		▼						123.41 masl Static water level
	122.39									122.69 masl Bottom of 100 mm ID set in a bentonite seal
	121.49	Soft brown clay								
		ENd of Hole								
10										
15										
20										

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BORERHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747
LOCATION Route 126 – Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R1b
DATES : BORING May 1991 WATER LEVEL 120.43 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES: TYPE	SAMPLES: NUMBER	SAMPLES: RECOVERY	SAMPLES: N - VALUE OR RQD	SAMPLES: HYDROCARB VAPORS	INSTRUMENTATION DETAILS
0	128.58	Top of Casing								
		OVERBURDEN Green sandy till changing to a red sandy till								
	126.18	Pebble and cobble till with sandy matrix								
5	123.98	Hard pan cemented till		▼						120.43 masl Static water level
	120.38	Red-brown clay, water saturated								
10	119.48	Red claystone. Moderately hard.								117.88 masl Bottom of 100 mm ID casing set in a bentonite seal
	117.98	Hard red siltstone								
	115.48	Moderately hard silty claystone. Reddish brown in colour								
15	113.78	Hard siltstone with interlayered claystone								
20	110.98	Very hard siltstone with interlayered sand lenses								
	105.78	End of Hole								

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R2a

DATES : BORING May 1991 WATER LEVEL 119.71 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0	102.80	Top of Casing								
		OVERBURDEN Clay rich sand and cobble till		▼						Static water level 119.71 masl
	117.80	Grey to green medium grained sandstone								Bottom of 100 mm ID -115.8 masl casing in a bentonite seal
5	116.80	Interbedded red siltstone and sandstone								-116.00 masl Fracture
	113.20	End of Hole								
10										
15										
20										

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R2b.

DATES: BORING May 1991 WATER LEVEL 119.21 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	121.32	Top of Casing								
		OVERBURDEN Reddish brown, sandy clayey till		▼						119.21 masl Static water level
	118.32	Reddish brown claystone soft								117.32 masl Fracture
5										
10										109.12 masl Bottom of 100 mm ID casing set in a bentonite seal
	108.42	Brown fine-grained sandstone								
	107.12									
	106.52	Brown siltstone								
15										
	105.42	Brown sandstone								
		Interbedded sand and siltstone								
	103.02	Claystone with grey sand lenses								
20	101.42	Interlayered brown and grey sandstone								
	100.12	Brown siltstone and claystone.								
	98.52	End of Hole								

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BOREHOLE RECORD

1/1

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE NºTH-R3a

DATES: BORING May 1991 WATER LEVEL 111.27 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
0	112.47	Top of Casing								
		OVERBURDEN 0-0.61 organic material 0.61-1.52 light brown silty, clayey soil Brown clay rich till		▼						Static water level 111.27 masl
5 10	108.17	Light brown to brown, fine to medium-grained siltstone units								- 106.07 masl Bottom of 100mm ID casing set in a bentonite seal
	100.27	Red claystone and siltstone								
15 20	98.77	Soft brown sandstone to siltstone with interlayers of claystone								
	89.67	End of Hole								Prepared by: MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

1/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R3b

DATES: BORING May 1991 WATER LEVEL 110.08 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB VAPORS	INSTRUMENTATION DETAILS
0	112.42	Top of Casing								
		OVERBURDEN 0.-0.61m organic material 0.61-1.52m light brown silty clayey soil Brown clay rich till		▼						Static water level 110.08 masl
	108.12									
5		Light brown to brown, fine to medium-grained siltstone units								
10	100.22									
		Red claystone and siltstone								
	98.82									
15		Soft brown sandstone to siltstone with interlayers of claystone								
20										

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BOREHOLE RECORD

2/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R3b

DATES: BORING May 1991 WATER LEVEL 110.08 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES TYPE	SAMPLES NUMBER	SAMPLES RECOVERY	SAMPLES N - VALUE OR RQD	SAMPLES HYDROCARB. VAPORS	INSTRUMENTATION DETAILS
0										
		Continued from previous page								
25										-85.62 masl Bottom of 100 mm ID casing set in a bentonite seal
30	82.02m	Fine-grained red sandstone - soft								
	78.22	Grey medium-grained sandstone								-78.22 Possible fracture masl
35										
	75.22	Interlayered red siltstone and claystone, minor lenses of sandstona grey								
40										

Prepared by: MGI MARITIME GROUNDWATER INC.

BOREHOLE RECORD

3/3

CLIENT ACI Limited FIELD LOG PROJECT Nº 747

LOCATION Route 126 - Proposed Landfill Site, Moncton, N.B. BOREHOLE Nº TH-R3B

DATES: BORING May 1991 WATER LEVEL 110.08 masl DATUM Sea Level

DEPTH (m)	ELEVATION (masl)	SOIL DESCRIPTION	STRATA PLOT	WATER LEVEL	SAMPLES					INSTRUMENTATION DETAILS
					TYPE	NUMBER	RECOVERY	N - VALUE OR RQD	HYDROCARB. VAPORS	
45		Continued from previous page								
	66.82	End of Hole								

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APPENDIX E

Water chemistry data for streams adjacent to proposed waste management facility sites

WATER CHEMISTRY DATA FOR STREAMS
ADJACENT TO PROPOSED WASTE MANAGEMENT FACILITY SITES
(A) DELONG DRIVE SITE, (B) BERRY MILLS ROAD SITE, AND (C) ROUTE 126 SITE

	SITES A & B															
	JONATHAN CREEK															
SAMPLE STATION #	#1				#2				#3				#4			
APRIL 1991 JUNE 1991 AUG. 1991 SEPT.1991	9th	25th	13th	13th	n.a.	25th	13th	13th	4th	25th	13th	13th	4th	25th	13th	13th
pH	6.97	n.a.	n.a.	n.a.	n.a.	7.70	7.30	7.00	6.98	7.65	7.45	7.00	7.23	7.75	7.50	7.20
Flow Rate l/sec	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	50.6	n.a.	n.a.
Alkalinity (mgCaCO3/l)	14.1	n.a.	n.a.	n.a.	n.a.	55.4	36.1	48.0	16.3	53.8	34.9	48.0	15.1	56.6	36.8	52.0
Nitrate - Nitrite	0.22	n.a.	n.a.	n.a.	n.a.	0.13	0.08	0.10	0.18	0.12	0.09	0.10	0.16	0.07	0.08	0.10
Total P	0.07	n.a.	n.a.	n.a.	n.a.	0.01	0.01	0.05	0.02	0.01	0.01	0.03	0.03	0.01	0.01	0.03
Suspended Solids	30.0	n.a.	n.a.	n.a.	n.a.	1.0	2.0	<1.0	8.0	<1.0	1.0	<1.0	12.0	1.0	1.0	<1.0
Total Dissolved Solids	n.a.	n.a.	n.a.	n.a.	n.a.	231.0	170.0	195.0	n.a.	234.0	161.0	190.0	n.c.	193.0	150.0	150.0
D.O.C.	n.a.	n.a.	n.a.	n.a.	n.a.	5.9	14.3	15.5	n.a.	5.5	13.4	13.4	n.a.	4.9	13.2	11.7
Aluminum (Al)	0.4	n.a.	n.a.	n.a.	n.a.	0.1	0.3	0.3	0.3	<0.1	0.1	0.2	0.3	<0.1	0.1	0.2
Cadmium (Cd)	<0.01	n.a.	n.a.	n.a.	n.a.	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu)	0.02	n.a.	n.a.	n.a.	n.a.	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Iron (Fe)	0.42	n.a.	n.a.	n.a.	n.a.	0.23	0.58	0.52	0.30	0.10	0.46	0.37	0.36	0.25	0.43	0.42
Mercury (Hg) $X10^{-4}$	<2.0	n.a.	n.a.	n.a.	n.a.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Lead (Pb)	<0.02	n.a.	n.a.	n.a.	n.a.	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (Zn)	0.01	n.a.	n.a.	n.a.	n.a.	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01

WATER CHEMISTRY DATA FOR STREAMS ADJACENT TO PROPOSED WASTE MANAGEMENT FACILITY SITES (A) DELONG DRIVE SITE, (B) BERRY MILLS ROAD SITE, AND (C) ROUTE 126 SITE

	SITE B																			
	SOMERS CREEK																			
SAMPLE STATION •	•5				•7				•8				•10				•11			
APRIL 1991 · JUNE 1991 · AUG. 1991 · SEPT.1991	11th	27th	13th	13th	4th	27th	14th	13th	4th	27th	14th	13th	4th	27th	13th	13th	4th	27th	13th	13th
pH	7.02	n.a.	7.15	7.00	5.65	n.a.	6.15	5.50	6.03	n.a.	n.a.	5.50	6.38	7.10	7.10	6.50	6.50	7.35	7.00	6.60
Flow Rate l/sec	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	0.125	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Alkalinity ($mgCaCO_3/l$)	13.7	n.a.	17.7	60.0	1.3	n.a.	7.2	4.0	3.2	n.a.	n.a.	8.0	5.5	36.5	16.9	20.0	5.6	38.6	19.9	26.0
Nitrate - Nitrite	0.38	n.a.	<0.01	<0.01	0.01	n.a.	<0.01	<0.01	0.01	n.a.	n.a.	<0.01	0.07	0.04	0.04	0.05	0.07	0.02	0.07	0.05
Total P	0.02	n.a.	0.02	0.03	0.01	n.a.	0.03	0.06	0.02	n.a.	n.a.	0.10	0.02	0.03	0.02	0.05	0.02	0.05	0.03	0.05
Suspended Solids	9.6	n.a.	1.0	2.5	0.2	n.a.	7.0	<1.0	1.1	n.a.	n.a.	15.5	1.2	4.0	1.0	<1.0	0.6	8.0	4.0	1.0
Total Dissolved Solids	n.a.	n.a.	96.0	220.0	n.a.	n.a.	96.0	56.0	n.a.	n.a.	n.a.	35.0	n.a.	113.0	96.0	50.0	n.a.	150.0	133.0	70.0
D.O.C.	n.a.	n.a.	14.9	11.7	n.a.	n.a.	28.0	33.4	n.a.	n.a.	n.a.	22.5	n.a.	10.2	26.2	20.2	n.a.	6.5	15.6	19.1
Aluminum (Al)	0.3	n.a.	0.1	0.2	0.2	n.a.	0.5	1.6	0.3	n.a.	n.a.	2.3	0.2	0.1	0.2	0.5	0.2	0.2	0.2	0.6
Cadmium (Cd)	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	n.a.	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper (Cu)	0.05	n.a.	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	n.a.	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Iron (Fe)	0.31	n.a.	0.46	0.40	0.14	n.a.	0.64	1.46	0.35	n.a.	n.a.	1.89	0.25	1.10	0.34	0.82	0.28	0.38	0.32	0.67
Mercury (Hg) $X10^{-4}$	<2.0	n.a.	<2.0	<2.0	<2.0	n.a.	<2.0	<2.0	<2.0	n.a.	n.a.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Lead (Pb)	<0.02	n.a.	<0.02	<0.02	<0.02	n.a.	<0.02	<0.02	<0.02	n.a.	n.a.	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zinc (Zn)	0.02	n.a.	<0.01	<0.01	0.01	n.a.	<0.01	<0.01	0.01	n.a.	n.a.	<0.01	0.01	0.01	<0.01	<0.01	0.01	0.01	0.01	<0.01

WATER CHEMISTRY DATA FOR STREAMS
ADJACENT TO PROPOSED WASTE MANAGEMENT FACILITY SITES
(A) DELONG DRIVE SITE, (B) BERRY MILLS ROAD SITE, AND (C) ROUTE 126 SITE

	SITE A																			
	MICHAEL'S CREEK																			
SAMPLE STATION •	•12				•13				•14				•15				•16			
APRIL 1991 JUNE 1991 AUG. 1991 SEPT.1991	9th	27th	13th	13th	n.a.	27th	13th	13th	9th	27th	13th	13th	n.a.	27th	13th	13th	n.a.	27th	13th	13th
pH	6.35	n.a.	6.85	6.30	n.a.	7.15	n.a.	n.a.	6.82	7.55	7.55	7.00	n.a.	6.65	6.60	5.90	n.a.	7.15	7.45	7.10
Flow Rate l/sec	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	69.3	n.a.	n.a.	n.a.	0.144	n.a.	n.a.	n.a.	50.1	n.a.	n.a.
Alkalinity (mgCaCO3/l)	4.4	n.a.	15.6	22.0	n.a.	55.8	n.a.	n.a.	14.1	59.4	59.7	58.0	n.a.	24.8	23.2	24.0	n.a.	54.7	47.1	34.0
Nitrate - Nitrite	0.03	n.a.	0.03	0.03	n.a.	0.43	n.a.	n.a.	0.13	0.37	0.56	0.50	n.a.	0.40	0.33	0.30	n.a.	0.46	0.10	0.08
Total P	0.01	n.a.	0.03	0.05	n.a.	0.31	n.a.	n.a.	0.11	0.24	0.22	0.19	n.a.	0.03	0.04	0.06	n.a.	0.24	0.06	0.09
Suspended Solids	1.4	n.a.	2.0	1.0	n.a.	6.0	n.a.	n.a.	36.0	11.0	3.0	4.0	n.a.	3.0	<1.0	<1.0	n.a.	4.0	7.0	6.5
Total Dissolved Solids	n.a.	n.a.	93.0	90.0	n.a.	203.0	n.a.	n.a.	n.a.	264.0	277.0	215.0	n.a.	143.0	111.0	80.0	n.a.	200.0	748.0	365.0
D.O.C.	n.a.	n.a.	22.1	23.7	n.a.	9.0	n.a.	n.a.	n.a.	9.6	11.8	15.0	n.a.	1.9	1.2	<1.0	n.a.	9.1	8.1	11.3
Aluminum (Al)	0.1	n.a.	0.2	0.3	n.a.	0.1	n.a.	n.a.	0.5	0.1	0.2	0.2	n.a.	<0.1	0.1	0.1	n.a.	0.1	0.1	0.6
Cadmium (Cd)	<0.01	n.a.	<0.01	<0.01	n.a.	<0.01	n.a.	n.a.	<0.01	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01
Copper (Cu)	0.01	n.a.	<0.01	<0.01	n.a.	0.02	n.a.	n.a.	0.03	0.03	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	0.02	<0.01	<0.01
Iron (Fe)	0.33	n.a.	1.25	0.72	n.a.	1.40	n.a.	n.a.	0.85	1.20	0.06	0.90	n.a.	0.05	0.34	0.06	n.a.	1.26	0.84	0.36
Mercury (Hg) X10^{-4}	<2.0	n.a.	<2.0	<2.0	n.a.	<2.0	n.a.	n.a.	<2.0	<2.0	<2.0	<2.0	n.a.	<2.0	<2.0	<2.0	n.a.	<2.0	<2.0	<2.0
Lead (Pb)	<0.02	n.a.	<0.02	<0.02	n.a.	<0.02	n.a.	n.a.	<0.02	<0.02	<0.02	<0.02	n.a.	<0.02	<0.02	<0.02	n.a.	<0.02	<0.02	<0.02
Zinc (Zn)	0.01	n.a.	0.02	<0.01	n.a.	0.03	n.a.	n.a.	0.04	0.03	0.14	<0.01	n.a.	0.01	0.01	<0.01	n.a.	0.02	0.02	<0.01

WATER CHEMISTRY DATA FOR STREAMS
ADJACENT TO PROPOSED WASTE MANAGEMENT FACILITY SITES
(A) DELONG DRIVE SITE, (B) BERRY MILLS ROAD SITE, AND (C) ROUTE 126 SITE

	SITE C															
	COCAGNE RIVER								SHAW BROOK							
SAMPLE STATION •	•17				•20				•21				•22			
APRIL 1991 JUNE 1991 AUG. 1991 SEPT.1991	9th	26th	13th	13th	9th	26th	13th	13th	n.a.	26th	13th	13th	n.a.	26th	13th	13th
pH	5.30	6.30	5.60	5.40	5.82	6.80	6.40	6.00	n.a.	7.15	7.05	6.60	n.a.	7.25	7.45	6.60
Flow Rate l/sec	n.a.	247.9	n.a.	n.a.	n.a.	730.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Alkalinity (mgCaCO3/l)	0.5	6.6	2.5	4.0	1.5	9.6	5.2	6.0	n.a.	22.3	13.5	18.0	n.a.	24.1	43.0	24.0
Nitrate - Nitrite	0.02	0.03	0.01	0.02	0.03	<0.01	<0.01	<0.01	n.a.	0.05	0.04	0.05	n.a.	0.02	0.03	0.02
Total P	0.01	0.04	0.04	0.07	0.02	0.03	0.03	0.07	n.a.	0.03	0.03	0.07	n.a.	0.01	0.03	0.05
Suspended Solids	1.1	6.0	3.0	8.0	4.0	3.0	4.0	2.0	n.a.	3.0	2.0	5.5	n.a.	2.0	10.0	2.0
Total Dissolved Solids	n.a.	54.0	75.0	25.0	n.a.	46.0	79.0	30.0	n.a.	102.0	92.0	85.0	n.a.	79.0	216.0	<1.0
D.O.C.	n.a.	19.1	31.6	32.2	n.a.	12.0	26.2	28.0	n.a.	10.1	18.3	22.5	n.a.	5.3	12.0	14.6
Aluminum (Al)	0.2	0.2	0.3	0.5	0.3	0.1	0.3	0.5	n.a.	0.1	0.2	0.6	n.a.	0.1	0.4	0.3
Cadmium (Cd)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01
Copper (Cu)	0.02	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	n.a.	<0.01	<0.01	<0.01	n.a.	0.01	<0.01	<0.01
Iron (Fe)	0.45	1.33	1.36	1.57	0.55	0.82	0.87	1.19	n.a.	0.52	0.68	1.10	n.a.	0.22	0.72	0.60
Mercury (Hg) X10^{-4}	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	n.a.	<2.0	<2.0	<2.0	n.a.	<2.0	<2.0	<2.0
Lead (Pb)	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	n.a.	<0.02	<0.02	<0.02	n.a.	<0.02	<0.02	<0.02
Zinc (Zn)	0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	n.a.	0.01	<0.01	<0.01	n.a.	0.01	0.01	<0.01

APPENDIX F

Electrofishing Results

STATION 3A

Raw Data For Qualitative Electrofishing Spot

Checks Completed For An Environmental Impact Assessment

DATE September 19, 1991

PERSONNEL T. McEachrean (Biologist), D. Steele (Electrofisher Operator)

LOCATION Station 3A - Jonathan Creek

ELECTROFISHER UNIT SETTINGS 60 Hz; 600 V

SAMPLING RUN TIME 1) APPROX 5 minutes 2) 4.8 minutes

SECTION LENGTH 1) 9.0 m / 16.7 m 2) 17.5 m

SECTION WIDTH 1) 6.5 m / 3.9 m 2) 2.5 m

GENERAL HABITAT DESCRIPTION 1) Pools with sandy bottom - H_2O depth approx 20 to 30 cm

2) Riffle type area with a low head barrier and undercut banks. The average H_2O depth is 8 cm

COMMENTS ON WEATHER Light drizzle with rain showers increasing in intensity as the run was completed

WATER TEMPERATURE 18°C

FISH CAPTURED 7 species / total of 56 individuals

NUMBER OF SPECIES PER LENGTH CLASS

SPECIES LENGTH CLASSES (cm)	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24		35
Notrops corautic (Common Shiner)				1	3	1	4																			
S. corporalis (Fallfish)			1		3	2																				
Catostomas commersoni (White sucker)							1	1	2			1	3	2	3	1	2	1	2			1				
Notrops loifrenatus (Bridle Shiner)		4		1	5	5																				
Rhinichthys atratulus (Blacknose Dace)			1		3																					
Salvelinas foutinalis (Brook Trout)										1																
Angnilla rostrata (American Eel)																										1

STATION 4

Raw Data For Qualitative Electrofishing Spot

Checks Completed For An Environmental Impact Assessment

DATE September 19, 1991

PERSONNEL T. McEachrean (Biologist), D. Steele (Electrofisher Operator)

LOCATION Station 4 - Jonathan Creek

ELECTROFISHER UNIT SETTINGS 60 Hz; 600 V

SAMPLING RUN TIME 1) 4.15 minutes 2) 7.67 minutes

SECTION LENGTH 1) 13.4 m 2) 36.5 m

SECTION WIDTH 1) 3 m 2) 2.5 m

GENERAL HABITAT DESCRIPTION 1) Plunge pool below culvert - H_2O depth > 1.5 m at the deepest point (the area sampled was 5-90 cm deep) and contained boulders and silt.

2) Riffle area with some gravel but gravel is mixed with sand and silt; H_2O depth approximately 12 cm

COMMENTS ON WEATHER Very cloudy, brief sunny periods with a strong threat of thunder showers.

WATER TEMPERATURE 16°C

FISH CAPTURED 8 species / total of 94 individuals

NUMBER OF SPECIES PER LENGTH CLASS

SPECIES \ LENGTH CLASSES (cm)	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Notrops coraulic (Common Shiner)		1		2	13	12	4		1	1																
S. corporalis (Fallfish)			3	7	11	5	2	1																		
Catostomas commersoni (White sucker)				1	4	2	3	2		1																
Notrops loifrenatus (Bridle Shiner)				4	1																					
Rhinichthys atratulus (Blacknose Dace)				2	4	2																				
Salvelinas foutinalis (Brook Trout)							1	2																		
Angnilla rostrata (American Eel)																									1	
Gasterosteus aculaetus (Three Spine Stickleback)			1																							

STATION 6A

Raw Data For Qualitative Electrofishing Spot

Checks Completed For An Environmental Impact Assessment

DATE September 19, 1991

PERSONNEL T. McEachrean (Biologist), D. Steele (Electrofisher Operator)

LOCATION Station 6A - Somers Creek

ELECTROFISHER UNIT SETTINGS 60 Hz; 600 V

SAMPLING RUN TIME 1) Approx 8 minutes 2) Approx 8 minutes

SECTION LENGTH 19 m

SECTION WIDTH 3.5 m

GENERAL HABITAT DESCRIPTION There was no visible current flow over a cobble/rock bottom with numerous patches of sand and silt. The bottom sediment is easily resuspended. The average H_2O depth in this alder rich section of the stream is 24 cm.

COMMENTS ON WEATHER Light drizzle but no thundershowers

WATER TEMPERATURE 17°C

FISH CAPTURED 5 species / total of 52 individuals

NUMBER OF SPECIES PER LENGTH CLASS

SPECIES / LENGTH CLASSES (cm)	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Notrops corautic (Common Shiner)		1	15		3	2	3	1	1																	
S. corporalis (Fallfish)		1	13	2	1	1																				
Catostomas commersoni (White sucker)																										
Notrops loifrenatus (Bridle Shiner)		1	2		1																					
Rhinichthys atratulus (Blacknose Dace)				1																						
Angnilia rostrata (American Eel)												1			1					1						

STATION 11

Raw Data For Qualitative Electrofishing Spot

Checks Completed For An Environmental Impact Assessment

DATE September 19, 1991

PERSONNEL T. McEachrean (Biologist), D. Steele (Electrofisher Operator)

LOCATION Station 11 - Somers Creek

ELECTROFISHER UNIT SETTINGS 60 Hz; 600 V

SAMPLING RUN TIME 1) 7.3 minutes 2) 7.4 minutes

SECTION LENGTH 1) 15 m 2) 9.5 m

SECTION WIDTH 1) 4.6 m 2) 6.9 m

GENERAL HABITAT DESCRIPTION Both sections 1 and 2 are Type 4 areas with respect to salmonoids. The bottoms are very silty and flow rate is sluggish (<0.1 m/sec). Water depth for section 1 ranged from <5 cm to 45 cm and section 2 from 10 cm to 50 cm

COMMENTS ON WEATHER Cloudy with the threat of severe thundershowers

WATER TEMPERATURE 18°C

FISH CAPTURED 5 species / total of 9 individuals

NUMBER OF SPECIES PER LENGTH CLASS

SPECIES \ LENGTH CLASSES (cm)	<2	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	30
Notrops corautic (Common Shiner)							1																			
S. corporalis (Fallfish)																										
Catostomas commersoni (White sucker)				1																						
Notrops loifrenatus (Bridle Shiner)			3																							
Rhinichthys atratulus (Blacknose Dace)																										
Salvelinas foutinalis (Brook Trout)																										
Angnilia rostrata (American Eel)															1			1								1
Gasterosteus aculaetus (Three Spine Stickleback)			1																							